User's Manual

Model 421

Gaussmeter

LakeShore.

LIMITED WARRANTY STATEMENT
WARRANTY PERIOD: ONE (1) YEAR

1. Lake Shore warrants that this Lake Shore product (the "Product") will be free from defects in materials and workmanship for the Warranty Period specified above (the "Warranty Period"). If Lake Shore receives notice of any such defects during the Warranty Period and the Product is shipped freight prepaid, Lake Shore will, at its option, either repair or replace the Product if it is so defective without charge to the owner for parts, service labor or associated customary return shipping cost. Any such replacement for the Product may be either new or equivalent in performance to new. Replacement or repaired parts will be warranted for only the unexpired portion of the original warranty or 90 days (whichever is greater).

2. Lake Shore warrants the Product only if it has been sold by an authorized Lake Shore employee, sales representative, dealer or original equipment manufacturer (OEM).

3. The Product may contain remanufactured parts equivalent to new in performance or may have been subject to incidental use.

4. The Warranty Period begins on the date of delivery of the Product or later on the date of installation of the Product if the Product is installed by Lake Shore, provided that if you schedule or delay the Lake Shore installation for more than 30 days after delivery the Warranty Period begins on the 31st day after delivery.

5. This limited warranty does not apply to defects in the Product resulting from (a) improper or inadequate maintenance, repair or calibration, (b) fuses, software and non-rechargeable batteries, (c) software, interfacing, parts or other supplies not furnished by Lake Shore, (d) unauthorized modification or misuse, (e) operation outside of the published specifications or (f) improper site preparation or maintenance.

6. TO THE EXTENT ALLOWED BY APPLICABLE LAW, THE ABOVE WARRANTIES ARE EXCLUSIVE AND NO OTHER WARRANTY OR CONDITION, WHETHER WRITTEN OR ORAL, IS EXPRESSED OR IMPLIED. LAKE SHORE SPECIFICALLY DISCLAIMS ANY IMPLIED WARRANTIES OR CONDITIONS OF MERCHANTABILITY, SATISFACTORY QUALITY AND/OR FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE PRODUCT. Some countries, states or provinces do not allow limitations on an implied warranty, so the above limitation or exclusion might not apply to you. This warranty gives you specific legal rights and you might also have other rights that vary from country to country, state to state or province to province.

7. TO THE EXTENT ALLOWED BY APPLICABLE LAW, THE REMEDIES IN THIS WARRANTY STATEMENT ARE YOUR SOLE AND EXCLUSIVE REMEDIES.

8. EXCEPT TO THE EXTENT PROHIBITED BY APPLICABLE LAW, IN NO EVENT WILL LAKE SHORE OR ANY OF ITS SUBSIDIARIES, AFFILIATES OR SUPPLIERS BE LIABLE FOR DIRECT, SPECIAL, INCIDENTAL, CONSEQUENTIAL OR OTHER DAMAGES (INCLUDING LOST PROFIT, LOST DATA OR DOWNTIME COSTS) ARISING OUT OF THE USE, INABILITY TO USE OR RESULT OF USE OF THE PRODUCT, WHETHER BASED IN WARRANTY, CONTRACT, TORT OR OTHER LEGAL THEORY, AND WHETHER OR NOT LAKE SHORE HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. Your use of the Product is entirely at your own risk. Some countries, states and provinces do not allow the exclusion of liability for incidental or consequential damages, so the above limitation may not apply to you.

LIMITED WARRANTY STATEMENT (Continued)

9. EXCEPT TO THE EXTENT ALLOWED BY APPLICABLE LAW, THE TERMS OF THIS LIMITED WARRANTY STATEMENT DO NOT EXCLUDE, RESTRICT OR MODIFY, AND ARE IN ADDITION TO, THE MANDATORY STATUTORY RIGHTS APPLICABLE TO THE SALE OF THE PRODUCT TO YOU.

CERTIFICATION

Lake Shore certifies that this product has been inspected and tested in accordance with its published specifications and that this product met its published specifications at the time of shipment. The accuracy and calibration of this product at the time of shipment are traceable to the United States National Institute of Standards and Technology (NIST); formerly known as the National Bureau of Standards (NBS).

FIRMWARE LIMITATIONS

Lake Shore has worked to ensure that the Model 421 firmware is as free of errors as possible, and that the results you obtain from the instrument are accurate and reliable. However, as with any computer-based software, the possibility of errors exists.

In any important research, as when using any laboratory equipment, results should be carefully examined and rechecked before final conclusions are drawn. Neither Lake Shore nor anyone else involved in the creation or production of this firmware can pay for loss of time, inconvenience, loss of use of the product, or property damage caused by this product or its failure to work, or any other incidental or consequential damages. Use of our product implies that you understand the Lake Shore license agreement and statement of limited warranty.

FIRMWARE LICENSE AGREEMENT

The firmware in this instrument is protected by United States copyright law and international treaty provisions. To maintain the warranty, the code contained in the firmware must not be modified. Any changes made to the code is at the user's risk. Lake Shore will assume no responsibility for damage or errors incurred as result of any changes made to the firmware.

Under the terms of this agreement you may only use the Model 421 firmware as physically installed in the instrument. Archival copies are strictly forbidden. You may not decompile, disassemble, or reverse engineer the firmware. If you suspect there are problems with the firmware, return the instrument to Lake Shore for repair under the terms of the Limited Warranty specified above. Any unauthorized duplication or use of the Model 421 firmware in whole or in part, in print, or in any other storage and retrieval system is forbidden.

TRADEMARK ACKNOWLEDGMENT

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PC, XT, AT, and PS-2 are trademarks of IBM.

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DECLARATION OF CONFORMITY

We: **Lake Shore Cryotronics, Inc.**
575 McCorkle Blvd.
Westerville OH 43082-8888 USA

hereby declare that the equipment specified conforms to the following Directives and Standards:

Application of Council Directives: **73/23/EEC**
89/336/EEC

Standards to which Conformity is declared: ....**EN 61010-1:2001**
Overvoltage II
Pollution Degree 2
EN 61326 A2:2001
Class A
Annex B

Model Number:...**421**

1-7-2004

Ed Maloof
Printed Name

Vice President of Engineering
Position

Electromagnetic Compatibility (EMC) for the Model 421 Gaussmeter

Electromagnetic Compatibility (EMC) of electronic equipment is a growing concern worldwide. Emissions of and immunity to electromagnetic interference is now part of the design and manufacture of most electronics. To qualify for the CE Mark, the Model 421 meets or exceeds the generic requirements of the European EMC Directive 89/336/EEC as a **CLASS A** product. A Class A product is allowed to radiate more RF than a Class B product and must include the following warning:

WARNING: **This is a Class A product. In a domestic environment, this product may cause radio interference in which case the user may be required to take adequate measures.**

The instrument was tested under normal operating conditions with sensor and interface cables attached. If the installation and operating instructions in the User's Manual are followed, there should be no degradation in EMC performance.

Pay special attention to instrument cabling. Improperly installed cabling may defeat even the best EMC protection. For the best performance from any precision instrument, follow the grounding and shielding instructions in the User's Manual. In addition, the installer of the Model 421 should consider the following:

• Leave no unused or unterminated cables attached to the instrument.

• Make cable runs as short and direct as possible.

• Do not tightly bundle cables that carry different types of signals.

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CHAPTER 1

INTRODUCTION

1.0   GENERAL

This chapter provides an introduction to the Lake Shore Model 421 Gaussmeter. The Model 421 was designed and manufactured in the United States of America by Lake Shore Cryotronics, Inc. The Model 421 is a highly accurate gaussmeter well suited for field work. It features:

- Resolution to 4¾ Digits.
- Large Vacuum Fluorescent Display.
- Serial Interface.
- Analog Voltage Outputs.
- Max Hold and Relative Reading.
- Alarm with Relay.

If you have just received your new Model 421, please proceed to Chapter 2 and become familiar with the installation instructions. Complete and detailed instrument and probe operational information is contained in Chapter 3. Chapter 4 contains details on remote operation using the Serial Interface. Details on accessories and probes are provided in Chapter 5. Limited service and rear panel connector definitions are contained in Chapter 6. Appendix A is a glossary of terminology. Appendix B provides units for magnetic properties. Finally, Appendix C provides information on Hall sensors and the Hallcal.exe program.

1.1   PRODUCT DESCRIPTION

The Model 421 Hall Effect Gaussmeter is the Lake Shore answer to the dynamic changes in the permanent magnet industry. Faster, higher resolution, and more repeatable flux density measurements are being demanded by manufacturing, quality assurance (QA), and research and development (R&D). The Model 421 is well suited to meet these requirements at an affordable price. The Model 421 is compatible with the extensive Lake Shore line of probes, or we can design custom probes to meet your unique needs. As an added advantage, the Model 421 is provided with one probe of customer choice.

421_Front.bmp

Figure 1-1. Model 421 Gaussmeter Front Panel

Product Description (Continued)

Performance

High-performance instrumentation is no longer the exclusive domain of research laboratories. Performance requirements are tightening in every magnetic measurement application. In response, the Model 421 offers improved accuracy, resolution, noise floor, and update rate.

Throughput

Throughput involves much more than update rate of an instrument. Usability of an instrument is just as important. The Model 421 has a large, bright, vacuum fluorescent display that can be seen easily in any lighting condition. The display updates quickly for fast feedback of probe or magnet positioning. The operation is straight forward with display prompts for the user. Max Hold, Alarm, and Sort features are included to streamline sorting and testing operations.

Automation

The Model 421 has a variety of interface features that are compatible with automated test configurations. The RS-232C Serial Interface can perform nearly every function of the instrument front panel. Two analog voltages and an alarm relay facilitate automation without a computer.

Probes

The Model 421 is delivered with one Lake Shore Hall probe of customer choice. A wide range of additional probes is available including Transverse, Axial, Flexible Transverse, and Gamma Probes™. Refer to Paragraph 5.2 for a complete list. Lake Shore probes are factory calibrated for accuracy and interchangeability. Calibration data is loaded into a PROM located in the probe connector so that it does not have to be entered by the user. Lake Shore can also custom design a probe to meet your specific application requirements.

Normal Reading

```
+102.84  G DC
```
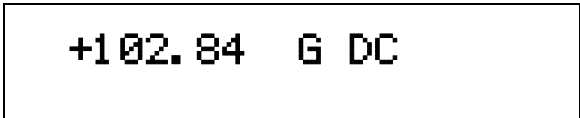
The Model 421 has a 2 line by 20 character vacuum fluorescent display with resolution to 4¾ digits. The display can accommodate seven measurement ranges from 300.00 mG to 300.00 kG. Measurements are displayed in either gauss or tesla.

Max Hold On

```
+102.84  G DC
+104.38  G MAX
```
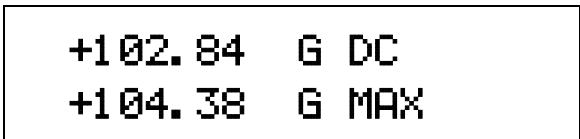
The largest field magnitude seen since the last Max Reset is displayed with the Max Hold function. The maximum value is shown in the lower display while the upper display contains the live reading.

Alarm On

```
+102.87  G DC        ♪
```
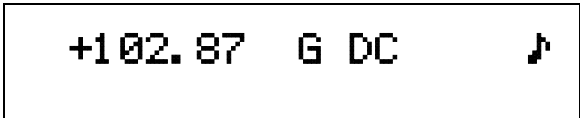
The alarm gives an audible and visual indication of when the field value is selectively outside or inside a user specified range. An output relay facilitates pass/fail actuation.

Sort On

```
+2.522  kG DC        ♪
       ** Pass **
```

The sort function allows the Model 421 to display pass or fail when it is used during repetitive testing. The live reading is shown in the upper display while the lower display contains the pass/fail message.

1.2   SPECIFICATIONS

General Measurement
Number Of Inputs: 1
Update Rate: 5 readings per second on display;
  up to 18 readings with serial interface
Probe Compatibility: Standard and custom probes,
  including Model 420 probes
Probe Features: Linearity Correction, Auto Probe Zero
Measurement Features: Auto Range, Max Hold,
  Relative Mode, Filter
Connector: 15 pin D style

DC Measurement
DC Display Resolution: 4¾ digits with filter,
  3¾ digits without filter

Range	Resolution w/Filter	Resolution w/out Filter
HST Probe		
300 kG	0.01 kG	0.1 kG
30 kG	0.001 kG	0.01 kG
3 kG	0.0001 kG	0.001 kG
300 G	0.01 G	0.1 G
HSE Probe		
30 kG	0.001 kG	0.01 kG
3 kG	0.0001 kG	0.001 kG
300 G	0.01 G	0.1 G
30 G	0.001 G	0.01 G
UHS Probe		
30 G	0.001 G	0.01 G
3 G	0.0001 G	0.001 G
300 mG	0.01 mG	0.1 mG

DC Accuracy: ±0.20% of reading ±0.05% of range
DC Temp. Coefficient: ±0.05% of reading ±0.03% of range/°C

AC RMS Measurement
AC Display Resolution: 3¾ digits

Range	Resolution
HST Probe	
300 kG	0.1 kG
30 kG	0.01 kG
3 kG	0.001 kG
300 G	0.1 G
HSE Probe	
30 kG	0.01 kG
3 kG	0.001 kG
300 G	0.1 G
30 G	0.01 G
UHS Probe	
30 G	0.01 G
3 G	0.001 G
300 mG	0.1 mG

AC Frequency Range: 10 – 400 Hz.
AC Accuracy: ±2% of reading (50 – 60 Hz.)
AC Frequency Response: 0 to –3.5% of reading (10 – 400 Hz.)
(All AC specs for sinusoidal input >1% of range. See Figure 3-3.)

Front Panel
Display Type: 2 line by 20 character, vacuum fluorescent
Display Resolution: To ±4¾ digits
Display Update Rate: 5 readings per second
Display Units: Gauss (G), Tesla (T)
Units Multipliers: µ, m, k
Annunciators: RMS   AC input signal
  DC   DC input signal
  MAX   Max Hold value
  ▲   Relative reading
  R   Remote Operation
  ♪   Alarm on
Keypad: 12 key membrane
Front Panel Features: Intuitive operation, display prompts, front
  panel lockout, brightness control

Interfaces
RS-232C Capabilities:
  Baud: 300, 1200, 9600
  Connector: 9 pin D style, DTE configuration
  Software Support: LabView Driver (consult Lake Shore for
    availability). Compatible with Model 420 command set.
Alarm
  Settings: High/low setpoint, Inside/Outside, Audible, Sort
  Actuators: Display annunciator, sort message, beeper, relay
Relay
  Number: 1
  Contacts: N.O., N.C., and common (C)
  Contact Rating: 30 VDC at 2 A
  Operation: Follows alarm
  Connector: Detachable terminal block
Monitor Analog Output
  Configuration: Real-time analog voltage output
  Range: ±3 V
  Scale: ±3 V = ±FS on selected range
  Frequency Response: DC to 400 Hz.
  Accuracy: Probe dependent
  Minimum Load Resistance: 1 kΩ (short-circuit protected)
  Connector: BNC
Corrected Analog Output
  Configuration: Voltage output generated by DAC
  Range: ±3 V
  Scale: ±3 V = ±FS on selected range
  Resolution: 1.25 mV
  Update Rate: 5 updates per second
  Accuracy: ±0.35%
  Minimum load resistance: 1 kΩ (short-circuit protected)
  Connector: BNC

General
Ambient Temperature: 15 – 35 °C at rated accuracy.
  5 – 40 °C with reduced accuracy.
Power Requirement: 100, 120, 220, 240 VAC (+5%, -10%),
  50 or 60 Hz, 20 watts
Size: 217 mm W × 90 mm H × 317 mm D, half rack
  (8.5 × 3.5 × 12.5 inches)
Weight: 3 kilograms (6.6 pounds)
Approval: CE Mark

Ordering Information
Part Number   Description
Instrument
421   Model 421 Gaussmeter plus one probe
                 (Specify line voltage and probe model number)

Accessories Included:
106-741   Terminal block for relay outputs
115-006   Detachable line cord (U.S.)
4060   Zero Gauss Chamber
MAN-421   Model 421 Gaussmeter User's Manual

Accessories Available:
RM-1/2   Rack mount kit for one ½ rack gaussmeter
                 in 483 mm (19 inch) rack
RM-2   Rack mount kit for two ½ rack gaussmeters
                 in 483 mm (19 inch) rack
MCBL-6   User programmable cable with PROM (6 feet)
MCBL-20   User programmable cable with PROM (20 feet)
MPEC-10   Probe extension cable with EEPROM (10 feet)
MPEC-25   Probe extension cable with EEPROM (25 feet)
MPEC-50   Probe extension cable with EEPROM (50 feet)
MPEC-100   Probe extension cable with EEPROM (100 feet)
                 (Extension cables must be matched to probes)
One Probe Included (refer to Paragraph 5.2 for details)
Custom Probes Available (consult Lake Shore for details)
Specifications subject to change without notice.

1.3 SAFETY SUMMARY

Observe the following general safety precautions during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Lake Shore Cryotronics, Inc. assumes no liability for customer failure to comply with these requirements.

The Model 421 protects the operator and surrounding area from electric shock or burn, mechanical hazards, excessive temperature, and spread of fire from the instrument. Environmental conditions outside of the conditions below may pose a hazard to the operator and surrounding area.

- Temperature: 5 – 40 °C.
- Maximum Relative Humidity: 80% for temperatures up to 31 °C decreasing linearly to 50% at 40 °C.
- Power supply voltage fluctuations not to exceed ±10% of the nominal voltage.

Ground The Instrument

To minimize shock hazard, connect instrument chassis and cabinet to an electrical ground. The instrument is equipped with a three-conductor AC power cable; either plug it into an approved three-contact outlet or use a three-contact adapter with the grounding wire (green) firmly connected to a ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet Underwriters Laboratories (UL) and International Electrotechnical Commission (IEC) safety standards.

Do Not Operate In An Explosive Atmosphere

Do not operate the instrument in the presence of flammable gases or fumes. It is a safety hazard.

Keep Away From Live Circuits Inside the Instrument

Operating personnel must not remove instrument covers. Refer component replacement and internal adjustments to qualified maintenance personnel. Do not replace components with power cable connected. To avoid injuries, always disconnect power and discharge circuits before touching them.

Do Not Substitute Parts Or Modify Instrument

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an authorized Lake Shore Cryotronics representative for service and repair to ensure that safety features are maintained.

Do Not Place Conductive Probes Against Exposed Electrical Circuits

Some gaussmeter probes are equipped with conductive sheaths. Keep these probes away from live electrical circuits.

1.4 SAFETY SYMBOLS

---	Direct current (power line).
∿	Alternating current (power line).
∿ (overline)	Alternating or direct current (power line).
3∿	Three-phase alternating current (power line).
⏚	Earth (ground) terminal.
⏚ (circle)	Protective conductor terminal.
⏚ (frame)	Frame or chassis terminal.
I	On (supply).
○	Off (supply).

Equipment protected throughout by double insulation or reinforced insulation (equivalent to Class II of IEC 536 - see Annex H).

Caution: High voltages; danger of electric shock. Background color: Yellow; Symbol and outline: Black.

Caution or Warning - See instrument documentation. Background color: Yellow; Symbol and outline: Black.

Fuse.

CHAPTER 2

INSTALLATION

2.0   GENERAL

This chapter provides general installation instructions for the Model 421 Gaussmeter. Inspection and unpacking instructions are provided in Paragraph 2.1. Repackaging for shipment instructions are provided in Paragraph 2.2. An definition of rear panel controls is provided in Paragraph 2.3. Finally, an initial setup and system checkout procedure is provided in Paragraph 2.4.

2.1   INSPECTION AND UNPACKING

Inspect shipping containers for external damage. All claims for damage (apparent or concealed) or partial loss of shipment must be made in writing to Lake Shore within five (5) days from receipt of goods. If damage or loss is apparent, please notify the shipping agent immediately.

Open the shipping containers. A packing list is included with the system to simplify checking that the instrument, probe(s), accessories, and manual were received. Please use the packing list and the spaces provided to check off each item as the instrument is unpacked. Inspect for damage. Be sure to inventory all components supplied before discarding any shipping materials. If there is damage to the instrument in transit, be sure to file proper claims promptly with the carrier and insurance company. Please advise Lake Shore Cryotronics of such filings. In case of parts or accessory shortages, advise Lake Shore immediately. Lake Shore cannot be responsible for any missing parts unless notified within 60 days of shipment. The standard Lake Shore Cryotronics, Inc. Warranty is included on the A Page (immediately behind the title page) of this manual.

2.2   REPACKAGING FOR SHIPMENT

If it is necessary to return the Model 421, probe(s), or accessories for repair or replacement, a Return Goods Authorization (RGA) number must be obtained from a factory representative before returning the instrument to our service department. When returning an instrument for service, the following information must be provided before Lake Shore can attempt any repair.

A. Instrument model and serial number.
B. User's name, company, address, and phone number.
C. Malfunction symptoms.
D. Description of system.
E. Returned Goods Authorization (RGA) number.

If possible, the original packing material should be retained for reshipment. If not available, consult Lake Shore for shipping and packing instructions.

Because of their fragility, Lake Shore probes are shipped in special cardboard and foam boxes. These boxes should be retained for storage of probes while the gaussmeter is not in use. The same box can be used to return probes to Lake Shore for recalibration or repair.

2.3   REAR PANEL DEFINITION

This paragraph provides a description of the Model 421 rear panel connections. The rear panel consists of the line input assembly, Serial I/O Connector, Probe Input Connector, Corrected and Monitor Analog Output BNCs, and Relay Terminal Block. This paragraph is provided for information only. Please read the entire paragraph then proceed to Paragraph 2.8 for the initial setup and system checkout procedure. Rear panel connector pin-out details are provided in Chapter 6 – Service.

CAUTION: Verify AC Line Voltage shown in the fuse holder window is appropriate for the intended AC power input. Also remove and verify the proper fuse is installed before plugging in and turning on the instrument.

CAUTION: Always turn off the instrument before making any rear panel connections. This is especially critical when making probe to instrument connections.
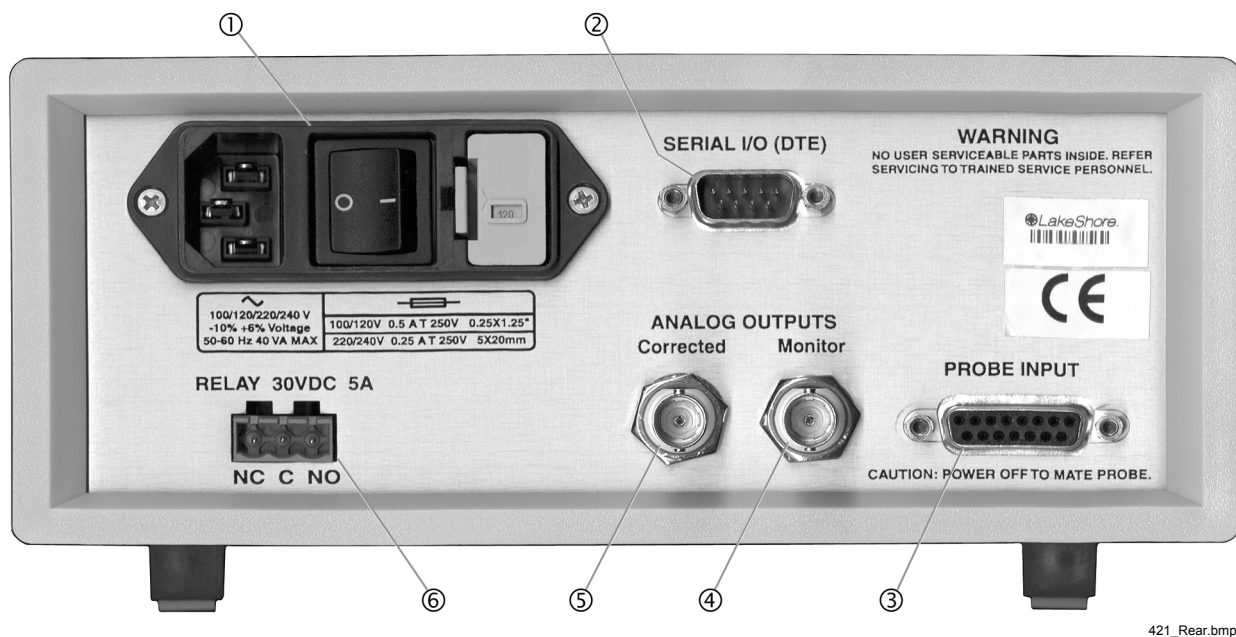
		Description	*Pin Definition*
①	Line Input Assembly	Paragraph 2.4	Figure 2-2
②	SERIAL I/O 9 pin D-Style Connector	Paragraph 4.1.1	Figure 6-5
③	PROBE INPUT 15 pin D-Style Connector	Paragraph 2.5	Figure 6-2
④	Monitor ANALOG OUTPUT BNC	Paragraph 2.6	Figure 6-3
⑤	Corrected ANALOG OUTPUT BNC	Paragraph 2.6	Figure 6-3
⑥	RELAY Terminal Block	Paragraph 2.7	Figure 6-4

Figure 2-1. Model 421 Rear Panel

2.4   LINE INPUT ASSEMBLY

This section covers line voltage and fuse verification in Paragraph 2.4.1, power cord in Paragraph 2.4.2, and power switch in Paragraph 2.4.3.

2.4.1   Line Voltage and Fuse Verification

To verify proper line voltage selection look at the indicator in the window on the fuse drawer of the line input assembly. Line voltage should be in the range shown in the specifications listed on the back of the instrument. See Figure 2-2. If not, change the line voltage selector per instructions in Paragraph 6.3. The fuse must be removed to verify its value, refer to the procedure in Paragraph 6.4. Use slow-blow fuses of the value specified on back of the instrument.

2.4.2   Power Cord

The Model 421 includes a three-conductor power cord. Line voltage is present across the outer two conductors. The center conductor is a safety ground and connects to the instrument metal chassis. For safety, plug the cord into a properly grounded three-pronged receptacle.

2.4.3   Power Switch

The power switch turns the instrument On and Off and is located in the line input assembly on the instrument rear. When **I** is raised, the instrument is On. When **O** is raised, the instrument is Off.
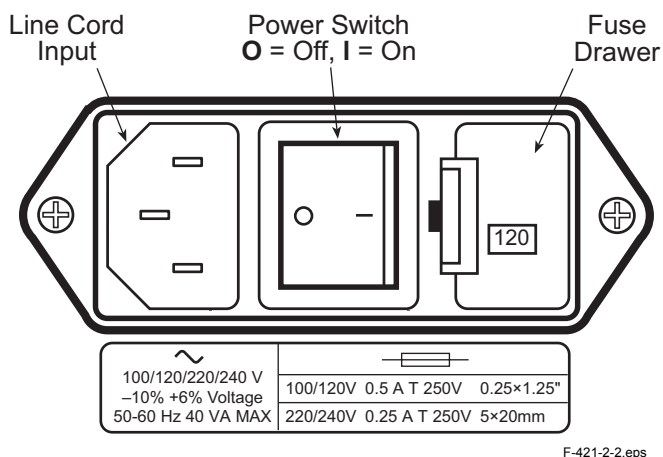
Figure 2-2. Line Input Assembly

2.5   PROBE INPUT CONNECTION

WARNING: Some probes used with the gaussmeter have conductive parts. Never probe near exposed live voltage. Personal injury and damage to the instrument may result.

CAUTION: Always turn off the instrument before making any rear panel Probe Input connections.

Lake Shore probes plug into the 15 pin D-style connector on the Model 421 rear panel. Turn the instrument off before attaching a probe. See Figure 8-3 for pin definitions.

When power is turned on, the instrument reads parameters from probe memory. The probe is ready to use. No parameters need to be entered into the Model 421. However, the Zero Probe function should be performed the first time a probe is used with the instrument and periodically during use.

2.5.1 Attachment To A Hall Generator

The Model MCBL-XX has a 15 pin D-Style connector on one end for direct attachment to the PROBE INPUT on the back panel of the Model 421 Gaussmeter. Four tinned wires are provided for connection to the Hall Generator. The leads may be soldered directly to these wires. The cable comes in two lengths: the MCBL-6 is 2 meters (6 feet) and the MCLB-20 is 6 meters (20 feet).

F-421-2-3.eps
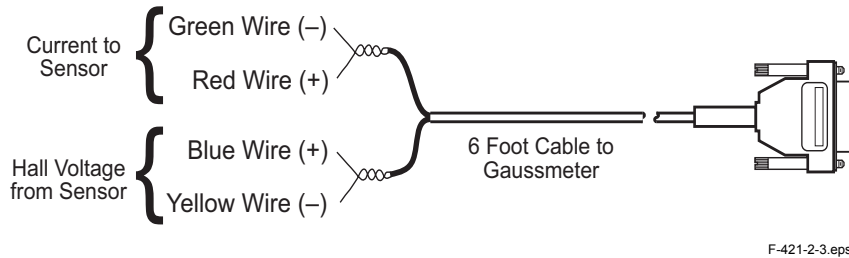
Figure 2-3. Model MCBL-XX User Programmable Cable Accessory

CAUTION: The Hall Generator should be isolated from all line voltages (or voltages referenced to earth ground). *If not, damage to the Model 421 Gaussmeter is almost a certainty.*

Refer to Appendix C for a complete list of compatible Hall generators manufactured by Lake Shore. Once connections are made, refer to Paragraph C6.0 for instructions on using the Hallcall.exe program to store probe parameters in the internal EPROM.

2.6 CORRECTED AND MONITOR ANALOG OUTPUTS

Analog outputs are available on two Bayonet Nut Connectors (BNCs). The signal is on the center conductor while the outer casing is for ground. Both outputs may be used simultaneously. The corrected output is not a real-time signal, but is updated at the same rate as the display. The range of the corrected output is ±3 volts equals ± full scale for the range. The monitor output is a live analog signal proportional to the magnetic flux density waveform. Refer to Paragraph 3.10 for further operational information.

2.7 RELAY TERMINAL BLOCK

The Model 421 has a single relay output that follows the alarm state. The relay outputs have a detachable 3-pin terminal block connector. The connector (included with the Model 421) can be removed from its socket for convenient installation of wires. The connector manufacturer indicates that up to 12 AWG stranded copper wire can be used with the connector.

CAUTION: Always turn off the instrument before making any rear panel terminal block connections.

Terminal	Description
1	Normally Closed (NC)
2	Common (C)
3	Normally Open (NO)

The terminal block has normally open (NO), normally closed (NC), and common (C) contacts in a Single Pole Double Throw (SPDT) configuration. The instrument provides no power through the relay; it opens and closes as switches relative to the alarm state. The contacts are rated at 30 VDC at 2 A. Refer to Paragraph 3.9 for alarm and relay operation.

2.8 INITIAL SETUP AND SYSTEM CHECKOUT PROCEDURE

The following procedure is an initial instrument setup and checkout procedure. The intent of this procedure is to verify basic operation of the unit before beginning use for measurements.

CAUTION: Check power source for proper voltage before connecting the line cord to the Model 421. Also check the power setting on the window in the fuse drawer. Damage to unit may occur if connected to improper voltage.

1. Check power source for proper voltage. The Model 421 operates with 100, 120, 220, or 240 (+5%, –10%) AC input voltage.

2. Check window in fuse drawer for proper voltage setting. If incorrect, refer to Paragraph 5.2.

3. Ensure the power switch is in the off (**O**) position.

CAUTION: The probe must be connected to the rear of the unit before applying power to the gaussmeter. Damage to the probe may occur if connected with power on.

4. Plug in the probe connector to PROBE INPUT. Use thumbscrews to tighten connector to unit.

5. Ensure any other rear panel connections (SERIAL I/O or ANALOG OUTPUTS) are connected before applying power to the unit.

6. Plug line cord into receptacle.

7. Turn the power switch to the on (**I**) position. The front panel display should turn on and the following message briefly appear.

```
Lake Shore 421
Field Monitor
```

8. The normal gaussmeter display will now appear. A typical display is illustrated below.

```
+ 0.001   G DC
```

NOTE: For best results, the instrument and probe should warm up for at least 5 minutes before zeroing the probe, and at least 30 minutes for rated accuracy. The probe and the zero gauss chamber should be at the same temperature.

NOTE: Some Lake Shore probes come with a clear plastic sleeve to protect the probe tip when not in use. The sleeve slides up and down the probe cable. To place the probe in the zero gauss chamber, slide the protective sleeve back, exposing the probe tip, before placing the tip in the chamber.

9. If so equipped, slide the clear plastic sleeve back, exposing the tip of the probe. Place the probe in the zero gauss chamber and press the front panel **Zero Probe** key. The display below appears.

```
Press Enter With
Probe At Zero
```

INITIAL SETUP AND SYSTEM CHECKOUT PROCEDURE (Continued)

10. Press the **Enter** key. The ✻CALIBRATING✻ message will briefly be displayed, followed by a return to the normal display.

NOTE: If the unit has performed well to this point, the unit is functioning properly. If you have a reference magnet available, you can continue with the test using the magnet to verify the accuracy of the Model 421.

11. If continuing the procedure with a reference magnet, ensure the probe can accommodate the range of the magnet. Use the **Range** key to select the proper range. Set the display for DC. Finally, since orientation of the probe is very selective, press the **Max Hold** key. This will capture the highest reading (normally the reference magnet calibration value).

CAUTION: Care must be exercised when handling the probe. The tip of the probe is very fragile. Any excess force may break the probe.

NOTE: Probe readings are dependent upon the angle of the tip in relation to the magnetic field. This and other effects on probe operation are explained in Paragraph 3.16.

12. Carefully place probe into reference magnet. You may have to hunt around a bit for the maximum reading. For this example, we are using a 999 ±1% Gauss Reference Magnet. Our reading appeared as follows:

```
+ 0.9720 kG DC
  0.9950 kG MAX
```

On the top line, the current reading is +0.9720 kG DC. On the bottom line, the maximum reading captured was 0.9950 kG, which is within the tolerance of the reference magnet. The top line will keep changing as the probe moves, but the bottom will remain fixed on the highest reading. To recapture a new maximum value, press the **Max Reset** key.

Once this abbreviated checkout procedure is successfully completed, the unit is ready for normal operation. Please proceed to Chapter 3 for further operational information.

CHAPTER 3

OPERATION

3.0   GENERAL

This chapter describes Model 421 Gaussmeter operation. The front panel controls are described in Paragraph 3.1. Paragraphs 3.2 thru 3.14 describe the various front panel functions in detail. Model 421 default settings are defined in Paragraph 3.15. Finally, Paragraph 3.16 provides probe handling considerations. Refer to Chapter 4 for detailed information on remote operation (serial interface).

3.1   DEFINITION OF FRONT PANEL CONTROLS

This paragraph provides a description of the front panel controls on the Model 421.

3.1.1   Front Panel Keypad

The keys on the front panel are defined as follows. Note the following are abbreviated descriptions of each key. A more detailed description of each function is provided in subsequent paragraphs.

Max Reset   Works with the Max Hold function. Clears Max reading back to current reading. Press and hold to reset parameters to default values. This key also acts as an escape key during numeric entry.

Max Hold   Turns the Max Hold feature on and off. Use **Max Reset** key to clear reading. Press and hold to lock keypad.

Zero Probe   Used to zero or null effects of ambient low level fields from the probe.

Range   Selects a manual field measurement range or Autorange. Available ranges are dependent on which probe is installed.

AC/DC   Selects periodic AC (RMS) or static (DC) magnetic fields. Press and hold to turn Filter on or off.
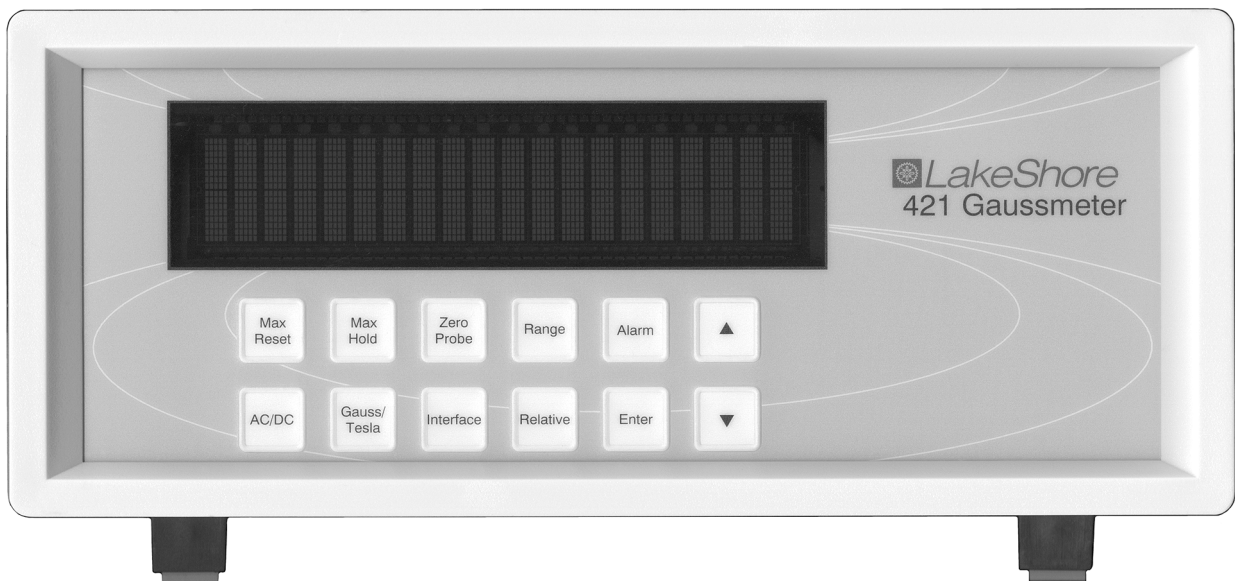
Figure 3-1. Model 421 Front Panel

Front Panel Keypad Definitions (Continued)

Gauss/Tesla	Changes display units from gauss to tesla. Gauss (G) is used in the cgs system, tesla (T) is used in the SI system, where $1\ T = 10^4\ G$.
Relative	Used to capture a relative setpoint, the display shows the positive or negative deviation from that setpoint. Press and hold to adjust the brightness of the vacuum florescent display.
Interface	The Serial Interface baud rate of the Model 421 transmissions may be changed from 300, 1200, or 9600. Press and hold to initiate Fast Data Mode from the front panel.
Alarm	Turns alarm feature on or off and allows entry of alarm setpoints. Press and hold to turn the audible beeper on or off, select the alarm to operate inside or outside the setpoint range, and turn the sort feature on or off.
▲	Toggles between various settings shown in the display and increments a numerical display.
▼	Toggles between various settings shown in the display and decrements a numerical display.
Enter	Accepts changes to parameter setting.

3.1.2   Front Panel Display

In normal operation, the 2 row by 20 character vacuum fluorescent display provides current magnetic readings on the top row and special information or readings on the bottom row. Other information is displayed when using the various functions on the keypad. Each character is comprised of a 5 by 7 dot matrix. See Figure 3-2. To change the display brightness, prefer to Paragraph 3.14.
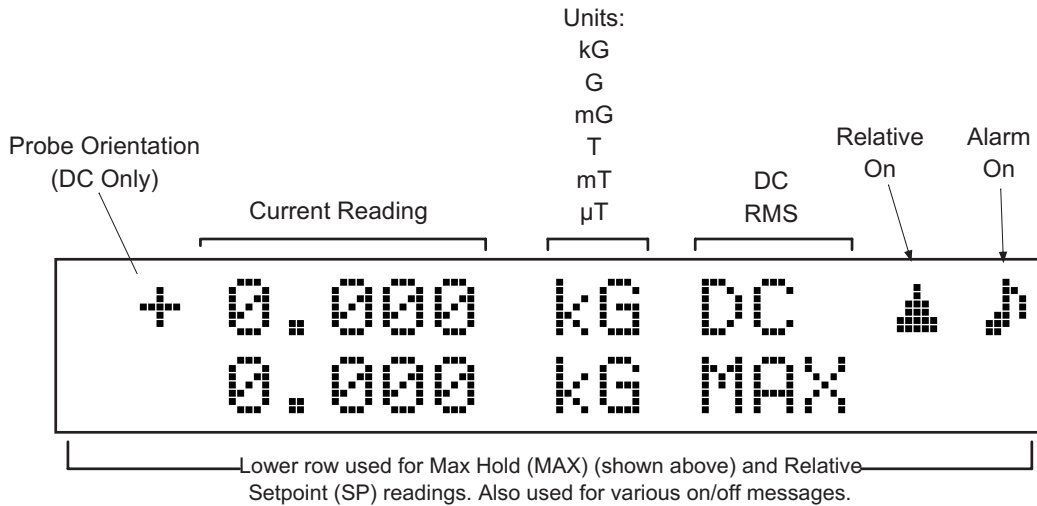
C-421-3-2.eps

Figure 3-2. Front Panel Display Definition

3.1.3   General Keypad Operation

Human interface with the instrument is provided by the 12 buttons that comprise the front panel keypad. Most operations can be performed through the front-panel keypad and monitored by watching the front panel display.

NOTE: Timeout is treated as escape, i.e., any changes made will not be retained if the display times out and returns to the main display.

There are five basic keypad operations:

1. **Direct Operation:** The following key functions occurs upon pressing the key: **Max Reset**, **Max Hold**, **Zero Probe**, **AC/DC**, **Gauss/Tesla**, and **Relative**.

2. **Direct Operation After Press And Hold:** The following key functions occurs immediately after pressing and holding a key: **Set Defaults**, **Lock Keypad**, and **Fast Data Mode**.

3. **Setting Selection:** The following functions will display a selection of settings immediately upon pressing a key: **Range**, **Baud Rate**, and **Alarm On/Off**. The arrow keys are active when you see the "⬆⬇" symbol on the display. Pressing the **Enter** key will enter parameter changes and return you to the main screen.

4. **Setting Selection After Press And Hold:** The following functions will display a selection of settings after pressing and holding a key: **Filter**, **Brightness**, **Audible Alarm**, **Alarm Inside/Outside**, and **Sort**. The arrow keys are active when you see the "⬆⬇" symbol on the display. Pressing the **Enter** key will enter parameter changes and return you to the main screen.

5. **Numeric Data Entry:** The high and low alarm setpoints require numeric data entry. Numbers can be entered with up to 5 digits of resolution in any field range available for the probe being used.

   To begin number entry look at the range and resolution of the present parameter value. If it is too small to accommodate the new value, or too large to allow appropriate resolution, change the setting range by pressing the **Range** key. Pressing the **Range** key will cycle through all available setting ranges and zero the setting value.

   The most significant digit of the entry value will blink to indicate that digit can be changed. Use the ▲ or ▼ keys to change that digit to the desired value. Digits should be set to zero if not used. Press the **Enter** key to advance to the next digit. Continue until all digits are set. When the **Enter** key is pressed on the last digit the setting value will be stored. If a mistake is made press the **Range** key to select a new range and start over or press **Max Reset** to escape out of the setting function.

3.2   GAUSS/TESLA

The Model 421 displays magnetic field values in gauss (G) or tesla (T). Pressing the **Gauss/Tesla** key toggles the display between the two units. The relation between gauss and tesla is 1 G = 0.0001 T, or 1 T = 10,000 G. When the field units are changed, relative and alarm setpoints are converted to the new units with no interruption in operation. The Corrected and Monitor Analog Outputs are not affected by a change in units.

When tesla is selected, the Model 421 displays AC or DC field values followed by T for tesla, mT for millitesla, or μT for microtesla. Field values available over the Serial Interface are formatted accordingly.

When gauss is selected, the Model 421 displays AC or DC field values followed by kG for kilogauss, G for gauss, or mG for milligauss. The field value available over the Serial Interface is formatted accordingly.

3.3 AC/DC

Pressing the **AC/DC** key toggles between AC and DC measurements. The annunciator immediately changes from DC to RMS, as applicable. However, one update cycle is required for a new display value.

In DC operation, the display shows the DC field at the probe with sign (orientation) followed by the appropriate field units and the letters DC. The DC value is available over the Serial Interface and both Analog Outputs. The resolution of DC readings is 3¾ digits when the filter feature is turn off and 4¾ digits when the filter is turned on.

In AC operation, the RMS readings will meet specified accuracy from 10 to 400 Hz. The AC RMS value is defined as the square root of the average of the square of the value of the function taken throughout one period. Frequency response and noise dominate the error present in AC mode. The Model 421 has a predictable frequency response which is illustrated in Figure 3-3.

The RMS value is available over the Serial Interface. A DC voltage representation of the RMS display reading is available from the Corrected Analog Output, while a true analog waveform is available from the Monitor Analog Output. (In fact, the Monitor Analog Output is not affected by the selection of AC or DC.) The resolution of AC RMS readings is fixed at 3¾ digits.

P-421-3-3.bmp
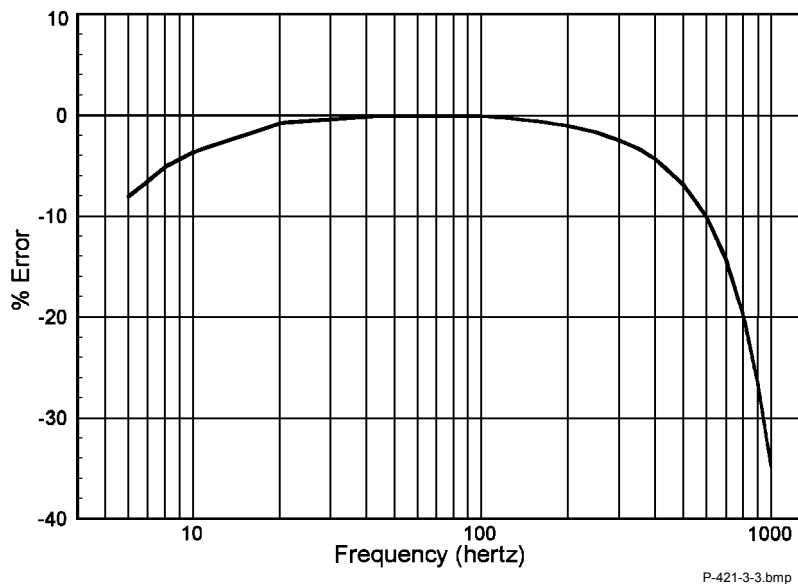
Figure 3-3. Model 421 AC Frequency Response

3.4 DISPLAY FILTER

The display filter function is used to quiet the display and make it more readable when the probe is exposed to a noisy field. Care should be taken when using the filter on changing fields because it may level off peaks and slow the response of the instrument. The filter also acts to quiet noise within the instrument, making an additional digit of usable resolution available with the filter on in DC. The filter function makes a linear average of 8 readings and settles in approximately 2 seconds.

To turn on the display filter, press and hold the **AC/DC** key for 5 seconds. The following display will appear.

```
Select With ▲▼
Filter   On  →Off
```

Use the ▲ or ▼ keys to toggle between On and Off. Press the **Enter** key to accept the new setting.

3.5 MANUAL RANGE AND AUTO RANGE

The Model 421 is capable of reading each of the Lake Shore probe types: High Stability (HST), High Sensitivity (HSE), or Ultra-High Sensitivity (UHS). The three probes permit the Model 421 to be used with ranges of 300 mG to 300 kG. The full-scale ranges for each probe type, along with the display resolution, are shown as follows.

Range	*DC Resolution with Filter*	*DC Resolution without Filter*	*AC RMS Resolution*
HST Probe			
300 kG	0.01 kG	0.1 kG	0.1 kG
30 kG	0.001 kG	0.01 kG	0.01 kG
3 kG	0.0001 kG	0.001 kG	0.001 kG
300 G	0.01 G	0.1 G	0.1 G
HSE Probe			
30 kG	0.001 kG	0.01 kG	0.01 kG
3 kG	0.0001 kG	0.001 kG	0.001 kG
300 G	0.01 G	0.1 G	0.1 G
30 G	0.001 G	0.01 G	0.01 G
UHS Probe			
30 G	0.001 G	0.01 G	0.01 G
3 G	0.0001 G	0.001 G	0.001 G
300 mG	0.01 mG	0.1 mG	0.1 mG

For manual ranging, pressing the **Range** key and the following display will appear.

```
Select With ▲▼
+/- 3.000  kG
```
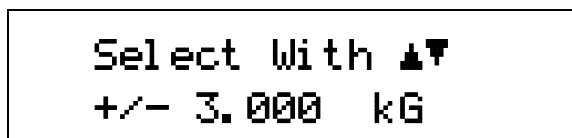
Use the ▲ or ▼ keys to toggle through the allowable full scale ranges for the probe installed. Press the **Enter** key to accept the new setting.

In Auto Range mode, the Model 421 selects the range with the best resolution for the field being measured. It can take up to 2 seconds for Auto Range to work, so manual ranging may be better in some conditions. Press the **Range** key.

```
Select With ▲▼
Auto Range
```
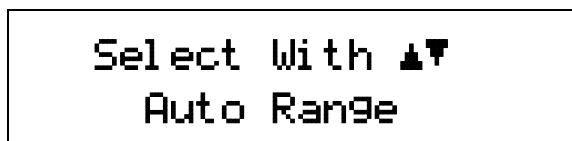
Use the ▲ or ▼ keys to toggle through the allowable full scale ranges until Auto Range is displayed. Press the **Enter** key to accept the new setting.

Auto Range should not be used with Max Hold operation or when alarms are active. Also, Auto Range should not be used when measuring small fields in a large background field, i.e., measuring a small DC field in presence of a large AC field, or measuring a small AC field in the presence of a large DC field.

3.6 ZERO PROBE

The zero probe function is used to null (cancel) out the zero offset of the probe or small magnetic fields. It is normally used in conjunction with the zero gauss chamber, but may also be used with an open probe (registering the local Earth magnetic field). Users wishing to cancel large magnetic fields should use the Relative function.

NOTE: For best results, the instrument and probe should warm up for at least 5 minutes before zeroing the probe, and at least 30 minutes for rated accuracy. The probe and the zero gauss chamber should be at the same temperature.

To zero the probe in the zero gauss chamber, first allow the temperature of the probe and chamber to be approximately equal. (A large temperature discrepancy affects the quality of the calibration.) Carefully place the probe tip into the chamber. Orientation of the probe is not critical. Once inserted, press the **Zero Probe** key and observe the following display.

```
Press Again With
Probe At Zero
```

Press the **Zero Probe** key. The *CALIBRATING* message is briefly displayed, followed by a return to the normal display. The probe is now calibrated. For best results, periodic zeroing of the probe is recommended.

3.7 MAX HOLD AND MAX RESET

The Max Hold function displays the largest field magnitude measured since the last Max Reset. When the **Max Hold** key is pressed, the maximum value is shown in lower line of the display while the upper line contains the current field reading.

```
+2.483  kG DC
 2.544  kG MAX
```

The **Max Reset** key clears the hold value. The hold value is also reset upon power up or when changing from AC or DC. Max Hold may also be used in conjunction with the Relative display (refer to Paragraph 3.8).

In DC operation, the Max Hold feature holds the field reading that is largest in magnitude. This is intended to monitor slowly changing signals. A field change not visible on the display can not be recorded in DC Max Hold. The display shows only the magnitude of the largest reading.

In AC RMS operation, the maximum RMS value is held.

3.8   RELATIVE

The relative function lets the user see small variations in larger fields. The setpoint (or center) of the relative reading is set when pressing the **Relative** key. This captures the current reading and effectively nulls the present field.

```
+1.420  kG DC

Relative On
```

Once the **Relative** key is pressed, the Relative On message is briefly shown on the lower line of the display. This is followed with the selected setpoint (SP) being displayed on the lower line and the current plus or minus deviation from that setpoint on the upper line. A small delta (▲) is also displayed to signify the relative display.

```
+0.000  kG DC        ▲
+1.420  kG SP
```

The relative feature also interacts with other features. When Relative and Max Hold functions are used at the same time, the relative reading is still in the top display with proper annunciators, but the bottom display shows the relative maximum instead of the relative setpoint.

```
+0.002  kG DC        ▲
+0.010  kG MAX
```

Pressing **Max Hold** again turns off the maximum hold function, returning the relative setpoint to the display. Pressing the **Relative** key turns off the relative function. The Relative Off message is briefly displayed.

3.9   ALARM AND RELAY

The alarm feature can be easily configured to perform several different tasks including error detection and limit testing. The most powerful application is manual magnet testing and sorting. A display annunciator, message display, beeper, and relay are all available to indicate an active alarm state. This section describes all of the parameters available for the alarm feature then gives examples to illustrate operation under different conditions.

When the alarm feature is on the alarm annunciator (♪) will appear in the top display. If there is an alarm condition the annunciator will flash to indicate the alarm is active. If there is not an alarm condition the annunciator will remain steady to indicate the alarm is in its normal state. Beeper and relay operation follow the alarm condition in a similar way when they are in use. The alarm function is non-latching so no action is required to reset the alarm. The alarm resets automatically when the alarm condition is no longer present.

To turn the alarm feature on press the **Alarm** key and the following display will appear.
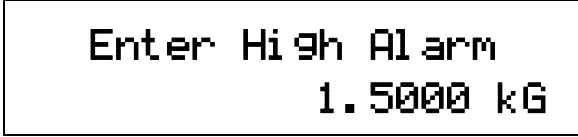
```
Select With  ▲▼
Alarm    →On   Off
```

Use the ▲ or ▼ keys to select between Alarm On and Off and press **Enter** to accept the new setting.

ALARM AND RELAY (Continued)

When the alarm is turned on, two additional setting screens will appear for high and low alarm setpoints. These values establish the limit for an error condition or the pass/fail limits for magnet testing. The values can be entered with the display resolution on any range available for the probe being used. The setpoint values are entered as positive numbers since the alarm feature uses the absolute (unsigned) value of field for comparison. Operation of the alarm setpoints is best understood when viewing the alarm inside/outside parameter examples below.

To enter the high alarm setpoint continue from Alarm On/Off or press the **Alarm** key and press the **Enter** key until the following display appears.
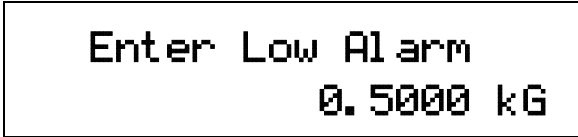
```
┌─────────────────────────────────┐
│                                 │
│    Enter High Alarm             │
│              1.5000 kG          │
│                                 │
└─────────────────────────────────┘
```

The high alarm setpoint requires numeric data entry. Numbers can be entered with up to 5 digits of resolution in any field range available for the probe being used.

To begin number entry look at the range and resolution of the present parameter value. If it is too small to accommodate the new value, or too large to allow appropriate resolution, change the setting range by pressing the **Range** key. Pressing the **Range** key will cycle through all available setting ranges and zero the setting value.

The most significant digit of the entry value will blink to indicate that digit can be changed. Use the ▲ or ▼ keys to change that digit to the desired value. Digits should be set to zero if not used. Press the **Enter** key to advance to the next digit. Continue until all digits are set. When the **Enter** key is pressed on the last digit the setting value will be stored. If a mistake is made press the **Range** key to select a new range and start over or press **Max Reset** to escape out of the setting function.

After entering the desired high alarm point, press **Enter** to accept the new value. The display proceeds to the Low Alarm Point as follows:

```
┌─────────────────────────────────┐
│                                 │
│    Enter Low Alarm              │
│              0.5000 kG          │
│                                 │
└─────────────────────────────────┘
```

The low alarm setpoint requires numeric data entry. Numbers can be entered with up to 5 digits of resolution in any field range available for the probe being used.

To begin number entry look at the range and resolution of the present parameter value. If it is too small to accommodate the new value, or too large to allow appropriate resolution, change the setting range by pressing the **Range** key. Pressing the **Range** key will cycle through all available setting ranges and zero the setting value.

The most significant digit of the entry value will blink to indicate that digit can be changed. Use the ▲ or ▼ keys to change that digit to the desired value. Digits should be set to zero if not used. Press the **Enter** key to advance to the next digit. Continue until all digits are set. When the **Enter** key is pressed on the last digit the setting value will be stored. If a mistake is made press the **Range** key to select a new range and start over or press **Max Reset** to escape out of the setting function.

The alarm setpoints are absolute (unsigned) i.e., only the magnitude of the field reading is used.

ALARM AND RELAY (Continued)

The Model 421 has an audible alarm annunciator or beeper. The beeper will sound when the instrument is in an active alarm state. If the sound of the beeper is not appropriate for your application, it can be turned on or off by the user. To turn the beeper on or off, press and hold the **Alarm** key until the following message appears.

```
Select With  ▲▼
Audible →On   Off
```

Use the ▲ or ▼ keys to cycle between audible alarm On or Off. Press **Enter** to accept the new value.

When the alarm feature is used to detect an error condition an active alarm state is expected when the field reading is higher than the high alarm setpoint or below the low alarm setpoint. This operation is achieved by setting the inside/outside parameter to outside. It is called outside because the alarm is active when the reading is outside the range of the two setpoints. During magnet testing or sorting it is often desirable to have the alarm active when the field reading is inside or between the two setpoints. This operation is achieved by setting the inside/outside parameter to inside. (see examples below)

To select inside/outside alarm operation, continue from Audible On/Off screen or press and hold the **Alarm** key until the Audible setting window appears, then press **Enter** until the following message appears.

```
Select With  ▲▼
Alarm    →In   Out
```

Use the ▲ or ▼ keys to cycle between the alarm triggered inside (In) or outside (Out) alarm setpoints. Press **Enter** to accept the changes.

Model 421 can be configured to display pass or fail when it is used during repetitive magnet testing or sorting operations. The sort message can be turned on or off as necessary and does not affect other operations of the alarm feature. When sort is turned on the lower display line will show:

Fail Low	Field below low alarm setpoint.
** Pass **	Field between the two alarm setpoints.
Fail High	Field above high alarm setpoint.

The message will use the lower display line during max hold or relative measurements. The live reading will be replaced during max hold operation and the relative setpoint will be replaced during relative operation.

To enable the sort message continue from Inside/Outside or press and hold the **Alarm** key until the Audible setting window appears then press the **Enter** key until the following message appears.

```
Select With  ▲▼
Sort     →On   Off
```

Use the ▲ or ▼ keys to select between Sort On and Off, then press **Enter** to accept the new setting.

ALARM AND RELAY (Continued)

The Model 421 has a single relay that is associated with alarm operation. The relay changes to its active state when the alarm is active and remains in its normal state when the alarm is not active. Relay terminals are located in a detachable terminal block on the instrument rear panel as described in Paragraph 2.7.

The following example details operation with the **Alarm Outside** setting. For example, if the reading is to be centered on 1 kG, with the high alarm point at 1.5 kG and the low alarm point at 0.5 kG, the following diagram illustrates when the alarm would be active or normal.
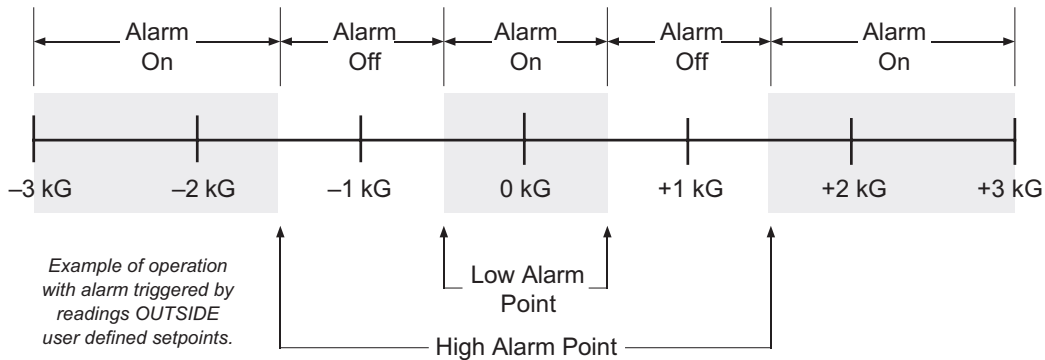
The following example details how the alarm operates in the **Alarm Inside** setting. The alarm inside setup is useful in situations where the user is looking for an indication of a good reading, such as incoming inspections. For example, you may be sorting a number of 1 kG magnets. The magnets have an acceptable tolerance of ±0.25 kG. With the high alarm point set to 1.25 kG and the low alarm point at 0.75 kG, the following diagram illustrates when the alarm would be active or normal.
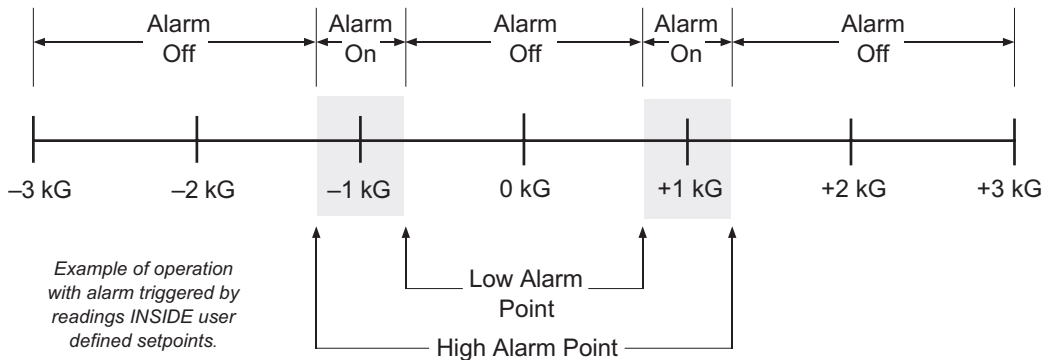
3.10 ANALOG OUTPUTS

There are two analog outputs available on the rear panel of the Model 421. They are the Corrected and Monitor Analog Outputs. Both outputs use BNC connectors with the center conductor carrying the signal and the outer portion the ground.

The Corrected Analog Output is a DC value proportional to the displayed field. The displayed field reading is corrected for probe nonlinearity and zero offset. This output is not a real time signal, but is updated at the same rate as the display. The range of the Corrected output is ±3 volts equals ± full scale for the selected range.

ANALOG OUTPUTS (Continued)

For the example below, the 3 kG range was selected.

Display Reading	–3 kG	–2 kG	–1 kG	0 kG	+1 kG	+2 kG	+3 kG
Output Voltage	–3 V	–2 V	–1 V	0 V	+1 V	+2 V	+3 V
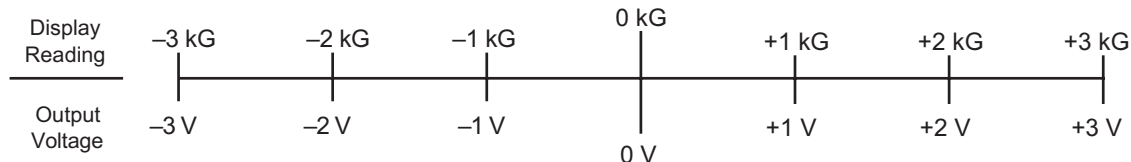
The Monitor Analog Output is a real-time analog signal proportional to the magnetic field. The scale of the Monitor Analog Output is ±3 volts for full scale of selected range. The Monitor Analog Output is not as accurate as the Corrected Monitor Output, but it has a full DC to 400 Hz. bandwidth.

3.11 INTERFACE PARAMETERS

If using the Serial Interface, the user must set the Baud rate. Baud is the only interface parameter that can be changed by the user. Refer to Chapter 4 for details on computer interface operation.

Pressing the **Interface** key brings up the following display.

```
Select With  ▲▼
Baud →3  12  96
```

Press the ▲ or ▼ key to cycle through the choices of 300, 1200, or 9600 Baud. Press the **Enter** key to accept the selected Baud rate.

3.12 FAST DATA MODE

In normal operation, the instrument updates the display, computer interface, and the corrected analog output at a rate of 5 readings per second. A Fast Data Mode has been included to increase the data rate when operating with the Serial Interface. While the corrected analog output update rate does correspond to the Fast Data Mode, the front panel display will not operate in this mode. When the Model 421 is operating in Fast Data Mode, the user will see the following front panel display:

```
Fast Data Mode
```

There are two methods for placing the instrument in Fast Data Mode: from the front panel or via the Serial Interface. From the front panel, press and hold the **Interface** key. The Fast Data Mode display (shown above) will appear. Press any other key to return the instrument to normal operation.

From the Serial Interface, use the following command:

FAST 1

To leave fast data mode, use the following command:

FAST 0

To query the status of Fast Data Mode, use the following command:

FAST?

In response to the query, a 0 will be returned if off and a 1 will be returned if on.

NOTE: When Fast Data Mode is activated, the following Model 421 functions are disabled: Relative, Max Hold, Alarms, and Autorange.

Use the normal interface command to query the field measurement data. Without display overhead, the instrument can take a maximum of 18 readings per second at 9600 Baud. When using the Serial Interface, never try to read faster than 18 readings a second.

3.13 LOCKING AND UNLOCKING THE KEYPAD

The Model 421 front panel keypad may be locked, preventing inadvertent changes to the settings. To lock the keypad, press and hold the **Max Hold** key (≈10 seconds) until the following display is seen.

```
Lock Keypad
```

The keypad is now locked. Any attempt to change settings causes the **LOCKED** message to briefly be displayed on the top line of the display. The only exception is the user may still use the **Alarm** key to turn off an alarm even though the keypad is locked.

To unlock the keypad, again press and hold the **Max Hold** key until the following display is seen.

```
Unlock Keypad
```

The keypad is now unlocked and the display will revert to the normal display.

3.14 DISPLAY BRIGHTNESS

The overall brightness of the front panel vacuum florescent display is user controllable. Press and hold the **Relative** key until you see the following display.

```
Select With ▲▼
Brightness
```
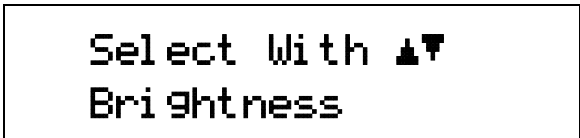
Use the ▲ or ▼ keys until you see the desired brightness. Press the **Enter** key to accept the new setting. There are four levels of brightness. The brightness can also be set using the BRIGT command via the Serial Interface. Using the highest brightness setting may shorten the life of the display.

3.15 FACTORY DEFAULT SETTINGS

Press and hold the **Max Reset** key for ≈20 seconds. This causes the following functions to return to their factory default settings. The defaults are listed as follows:

```
AC/DC........................... DC
Alarm ........................... Off
Auto Range.................... Off
Baud ............................ 300
Brightness..................... 4
Fast Data Mode ............ Off
Filter............................. Off
Gauss/Tesla.................. Gauss
Keypad.......................... Not Locked
Max Hold....................... Off
Range .......................... Highest Range For Probe
Relative......................... Off
```

Other gaussmeter calibration information and probe data are not affected by this reset. Zero the probe after this operation.

3.16 PROBE CONSIDERATIONS

To avoid damage and for best results during use, the probes have a number of handling and accuracy requirements that must be observed. Changing probes is discussed in Paragraph 3.16.1. Probe handling is discussed in Paragraph 3.16.2. Probe operation is discussed in Paragraph 3.16.3. Finally, accuracy considerations are provided in Paragraph 3.16.4.

3.16.1 Changing Probes

A 512-byte Electrically Erasable Programmable Read Only Memory (EEPROM) is included in each probe. The EEPROM stores specific information that the gaussmeter requires for operation. The information includes serial number, probe sensitivity, and field compensation data.

CAUTION: The probe must be connected to the rear of the instrument before applying power to the gaussmeter. Probe memory may be erased if connected with power on.

When the instrument is powered up, the probe memory is downloaded to the gaussmeter. This is how the gaussmeter knows which ranges are available and which error correction to apply. To change probes, first turn power off, remove the existing probe, and then plug in the new probe. When power is restored, the characteristics of the new probe are downloaded to the gaussmeter memory. Normal operation may continue after the new probe offset is nulled using the Zero Probe operation.

If the instrument is powered up with no probe attached, the following message is displayed.

```
* * NO PROBE * *
Power off,attach
```

3.16.2 Probe Handling

Although every attempt has been made to make the probes as sturdy as possible, the probes are still fragile. This is especially true for the exposed sensor tip of some transverse probes. Care should be taken during measurements that no pressure is placed on the tip of the probe. The probe should only be held in place by securing at the handle. The probe stem should never have force applied. Any strain on the sensor may alter the probe calibration, and excessive force may destroy the Hall generator.

CAUTION: Care must be exercised when handling the probe. The tip of the probe is very fragile. Stressing the Hall sensor can alter its calibration. Any excess force can easily break the sensor. Broken sensors are not repairable.

Avoid repeated flexing of the stem of a flexible probe. As a rule, the stem should not be bent more than 45° from the base. See Figure 3-4. Force should never be applied to the tip of the probe. On all probes, do not pinch or allow cables to be struck by any heavy or sharp objects. Although damaged or severed cables should be returned to Lake Shore for repair, please understand that probes are not always repairable.

When probes are installed on the gaussmeter but not in use, the protective tubes provided with many probes should be placed over the probe handle and stem in order to protect the tip. When the gaussmeter is not in use, the probes should be stored separately in some type of rigid container. The cardboard and foam container that Lake Shore probes are shipped in may be retained for probe storage. For further details on available accessories and probes, refer to Chapter 5.
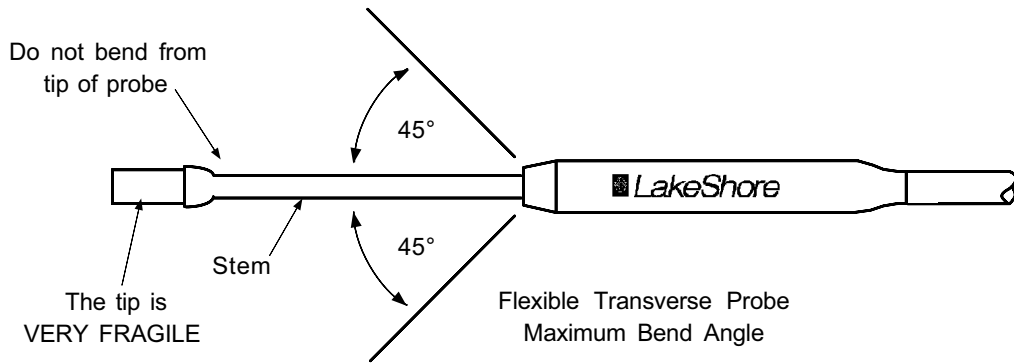
C-421-3-4.eps

Figure 3-4. Maximum Flexible Probe Bend Radius

3.16.3 Probe Operation

In the DC mode of operation, the orientation of the probe affects the polarity reading of the gaussmeter. On a transverse probe, the Lake Shore name printed on the handle indicates the side for positive (+) flux entry. On an axial probe, positive (+) flux entry is always from the front of the probe. See Figure 3-5.

NOTE: For best results, the instrument and probe should warm up for at least 5 minutes before zeroing the probe, and at least 30 minutes for rated accuracy. The probe and the zero gauss chamber should be at the same temperature.

If the exact direction of the magnetic field is unknown, the proper magnitude is determined by turning on **Max Hold** and slowly adjusting the probe. As the probe turns and the measured field rises and falls, its maximum value is held on the display. Make note of the probe orientation at the maximum reading to identify the field orientation.
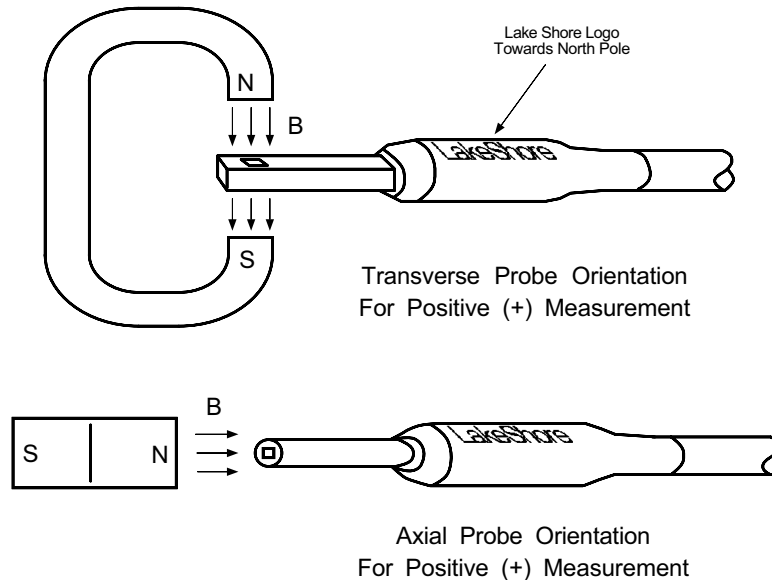
C-421-3-5.eps

Figure 3-5. Probe Orientation For Positive Measurement

3.16.4 Probe Accuracy Considerations

NOTE: Probe readings are dependent upon the angle of the sensor in relation to the magnetic field. The farther from 90° the angle between the probe and the field, the greater the percentage of error. For example, a 5° deviation causes a 0.4% error, a 10° deviation causes a 1.5% error, etc.

NOTE: For best results, the instrument and probe should warm up for at least 5 minutes before zeroing the probe, and at least 30 minutes for rated accuracy. The probe and the zero gauss chamber should be at the same temperature.

The user must consider all the possible contributors to the accuracy of the reading. Both the probe and gaussmeter have accuracy specifications that may impact the actual reading. The probe should be zeroed before making critical measurements. The zero probe function is used to null (cancel) out the zero offset of the probe or small magnetic fields. It is normally used in conjunction with the zero gauss chamber, but may also be used with an open probe (registering the local earth magnetic field). Users wishing to cancel out large magnetic fields should use the Relative function. Refer to Paragraph 3.8.

Probe temperature can also affect readings. Refer to the two separate temperature coefficients listed on the specification sheet. The High Stability (HST) probes exhibit a low temperature coefficient of gain due to the inherent thermal stability of the materials used in its construction.

Probe readings are dependent on the angle of the sensor (Hall sensor) in relation to the magnetic field. Maximum output occurs when the flux vector is perpendicular to the plane of the sensor. This is the condition that exists during factory calibration. The greater the deviation from orthogonality (from right angles in either of three axes), the larger the error of the reading. For example, a 5° variance on any one axis causes a 0.4% error, a 10° misalignment induces a 1.5% error, etc. See Figure 3-6.

Tolerance of instrument, probe, and magnet must be considered for making critical measurements. The accuracy of the gaussmeter reading is better than ±0.20% of reading and ±0.05% of range. Absolute accuracy readings for gaussmeters and Hall probes is a difficult specification to give, because all the variables of the measurement are difficult to reproduce. For example, a 1° error in alignment to the magnetic field causes a 0.015% reading error. Finally, the best probes have an accuracy of ±0.15%. This implies that the absolute accuracy measurement of a magnetic field is not going to reliably be better than ±0.15% under the best of circumstances, and more likely to be 0.20% to 0.25%.
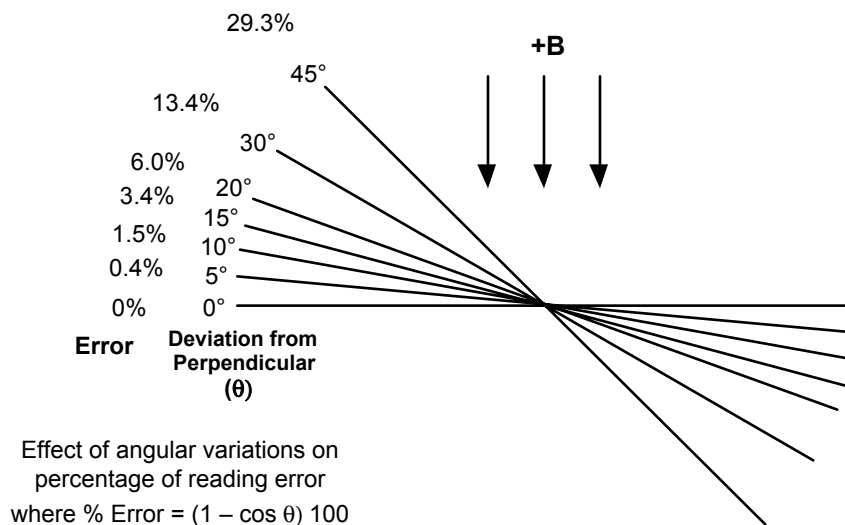
Figure 3-6. Effect Of Angle On Measurements

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CHAPTER 4

REMOTE OPERATION

4.0   GENERAL

The Model 421 is equipped with an RS-232C serial computer interface. The interface allows computer automation of instrument setup and field measurement data collection. Nearly every feature of the instrument can be accessed through the computer interface. Interface capabilities including setup information and Basic programs are provided in Paragraph 4.1. Interface commands including a command summary are described in Paragraph 4.2.

4.1   SERIAL INTERFACE OVERVIEW

The serial interface used in the Model 421 is commonly referred to as an RS-232C interface. RS-232C is a standard of the Electronics Industries Association (EIA) that describes one of the most common interfaces between computers and electronic equipment. The RS-232C standard is quite flexible and allows many different configurations. However, any two devices claiming RS-232C compatibility cannot necessarily be plugged together without interface setup. The remainder of this paragraph briefly describes the key features of a serial interface that are supported by the instrument. A customer supplied computer with similarly configured interface port is required to enable communication.

4.1.1   Physical Connection

The Model 421 has a 9 pin D-Subminiature plug on the rear panel for serial communication. The original RS-232C standard specifies 25 pins but both 9- and 25-pin connectors are commonly used in the computer industry. Many third party cables exist for connecting the instrument to computers with either 9- or 25-pin connectors. Paragraph 6.5 gives the most common pin assignments for 9- and 25-pin connectors. Please note that not all pins or functions are supported by the Model 421.

The instrument serial connector is the plug half of a mating pair and must be matched with a socket on the cable. If a cable has the correct wiring configuration but also has a plug end, a "gender changer" can be used to mate two plug ends together.

The letters DTE near the interface connector stand for Data Terminal Equipment and indicate the pin connection of the directional pins such as transmit data (TD) and receive data (RD). Equipment with Data Communications Equipment (DCE) wiring can be connected to the instrument with a straight through cable. As an example, pin 3 of the DTE connector holds the transmit line and pin 3 of the DCE connector holds the receive line so the functions complement.

It is likely both pieces of equipment are wired in the DTE configuration. In this case pin 3 on one DTE connector (used for transmit) must be wired to pin 2 on the other (used for receive). Cables that swap the complementing lines are called null modem cables and must be used between two DTE wired devices. Null modem adapters are also available for use with straight through cables. Paragraph 6.5.1 illustrates suggested cables that can be used between the instrument and common computers.

The instrument uses drivers to generate the transmission voltage levels required by the RS-232C standard. These voltages are considered safe under normal operating conditions because of their relatively low voltage and current limits. The drivers are designed to work with cables up to 50 feet in length.

4.1.2   Hardware Support

The Model 421 interface hardware supports the following features. Asynchronous timing is used for the individual bit data within a character. This timing requires start and stop bits as part of each character so the transmitter and receiver can resynchronized between each character. Half duplex transmission allows the instrument to be either a transmitter or a receiver of data but not at the same time. Communication speeds of 300, 1200 or 9600 baud are supported. The Baud rate is the only interface parameter that can be changed by the user.

Hardware handshaking is not supported by the instrument. Handshaking is often used to guarantee that data message strings do not collide and that no data is transmitted before the receiver is ready. In this instrument appropriate software timing substitutes for hardware handshaking. User programs must take full responsibility for flow control and timing as described in Paragraph 4.1.5.

4.1.3   Character Format

A character is the smallest piece of information that can be transmitted by the interface. Each character is 10 bits long and contains data bits, bits for character timing and an error detection bit. The instrument uses 7 bits for data in the ASCII format. One start bit and one stop bit are necessary to synchronize consecutive characters. Parity is a method of error detection. One parity bit configured for odd parity is included in each character.

ASCII letter and number characters are used most often as character data. Punctuation characters are used as delimiters to separate different commands or pieces of data. Two special ASCII characters, carriage return (CR 0DH) and line feed (LF 0AH), are used to indicate the end of a message string.

Table 4-1. Serial Interface Specifications

Connector Type:	9-pin D-style plug
Connector Wiring:	DTE
Voltage Levels:	EIA RS-232C Specified
Transmission Distance:	50 feet maximum
Timing Format:	Asynchronous
Transmission Mode:	Half Duplex
Baud Rate:	300, 1200, 9600
Handshake:	Software timing
Character Bits:	1 Start, 7 Data, 1 Parity, 1 Stop
Parity:	Odd
Terminators:	CR(0DH) LF(0AH)
Command Rate:	20 commands per second maximum

4.1.4   Message Strings

A message string is a group of characters assembled to perform an interface function. There are three types of message strings commands, queries and responses. The computer issues command and query strings through user programs, the instrument issues responses. Two or more command strings can be chained together in one communication but they must be separated by a semi-colon (;). Only one query is permitted per communication but it can be chained to the end of a command. The total communication string must not exceed 64 characters in length.

A command string is issued by the computer and instructs the instrument to perform a function or change a parameter setting. The format is <command mnemonic><space><parameter data><terminators>. Command mnemonics are listed in Paragraph 4.2. Parameter data necessary for each one is described in Paragraph 4.2.1. Terminators must be sent with every message string.

Message Strings (Continued)

A query string is issued by the computer and instructs the instrument to send a response. The query format is <query mnemonic><?><space><parameter data><terminators>. Query mnemonics are often the same as commands with the addition of a question mark. Parameter data is often unnecessary when sending queries. Query mnemonics are listed in Paragraph 4.2. Parameter data if necessary is described in Paragraph 4.2.1. Terminators must be sent with every message string. The computer should expect a response very soon after a query is sent.

A response string is the instruments response or answer to a query string. The instrument will respond only to the last query it receives. The response can be a reading value, status report or the present value of a parameter. Response data formats are listed along with the associated queries in Paragraph 4.2.1. The response is sent as soon as possible after the instrument receives the query. Typically it takes 10 ms for the instrument to begin the response. Some responses take longer.

4.1.5 Message Flow Control

It is important to remember that the user program is in charge of the serial communication at all times. The instrument can not initiate communication, determine which device should be transmitting at a given time or guarantee timing between messages. All of this is the responsibility of the user program.

When issuing commands only the user program should:

- Properly format and transmit the command including terminators as one string.
- Guarantee that no other communication is started for 50 ms after the last character is transmitted.
- Not initiate communication more than 20 times per second.

When issuing queries or queries and commands together the user program should:

- Properly format and transmit the query including terminators as one string.
- Prepare to receive a response immediately.
- Receive the entire response from the instrument including the terminators.
- Guarantee that no other communication is started during the response or for 50 ms after it completes.
- Not initiate communication more than 20 times per second.

Failure to follow these simple rules will result in inability to establish communication with the instrument or intermittent failures in communication.

4.1.6 Changing Baud Rate

To use the Serial Interface, you must first set the Baud rate. Press **Interface** key to display the following screen.

```
Select With ▲▼
Baud →3  12  96
```

Press the ▲ or ▼ keys to cycle through the choices of 300, 1200, or 9600 Baud. The rate selected will have a right pointing arrow (→) immediately to the left. Press **Enter** to accept the new number.

4.1.7   Serial Interface Basic Programs

Two BASIC programs are included to illustrate the serial communication functions of the instrument. The first program was written in Visual Basic. Refer to Paragraph 4.1.7.1 for instructions on how to setup the program. The Visual Basic code is provided in Table 4-3. The second program was written in Quick Basic. Refer to Paragraph 4.1.7.2 for instructions on how to setup the program. The Quick Basic code is provided in Table 4-4. Finally, a description of operation common to both programs is provided in Paragraph 4.1.7.3. While the hardware and software required to produce and implement these programs not included with the instrument, the concepts illustrated apply to almost any application where these tools are available.

4.1.7.1   Visual Basic Serial Interface Program Setup

The serial interface program (Table 4-3) works with Visual Basic 6.0 (VB6) on an IBM PC (or compatible) with a Pentium-class processor. A Pentium 90 or higher is recommended, running Windows 95 or better, with a serial interface. It uses the COM1 communications port at 9600 Baud. Use the following procedure to develop the Serial Interface Program in Visual Basic.

1. Start VB6.
2. Choose Standard EXE and select Open.
3. Resize form window to desired size.
4. On the Project Menu, click Components to bring up a list of additional controls available in VB6.
5. Scroll through the controls and select Microsoft Comm Control 6.0. Select OK. In the toolbar at the left of the screen, the Comm Control will have appeared as a telephone icon.
6. Select the Comm control and add it to the form.
7. Add controls to form:
    a.   Add three Label controls to the form.
    b.   Add two TextBox controls to the form.
    c.   Add one CommandButton control to the form.
    d.   Add one Timer control to the form.
8. On the View Menu, select Properties Window.
9. In the Properties window, use the dropdown list to select between the different controls of the current project.
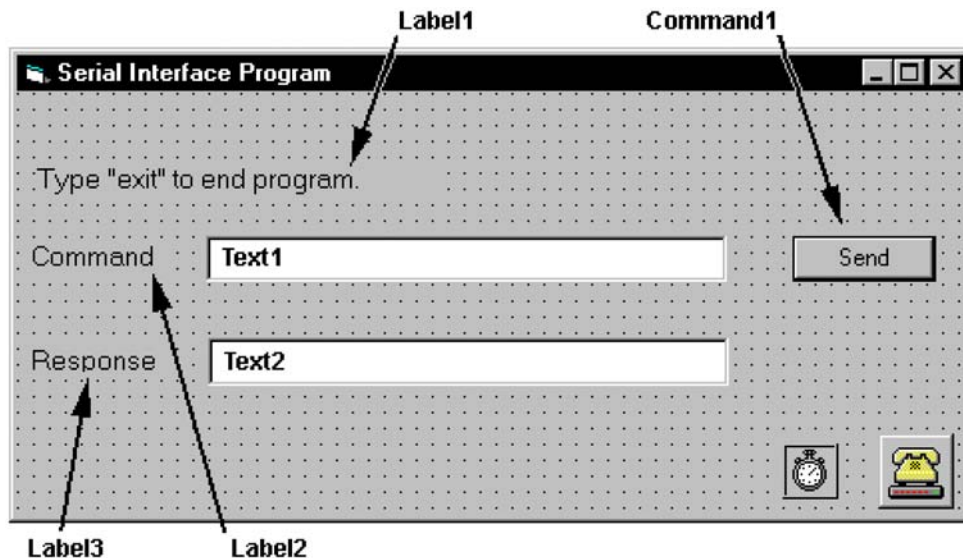
10. Set the properties of the controls as defined in Table 4-2.
11. Save the program.

Table 4-2. Serial Interface Program Control Properties

Current Name	Property	New Value
Label1	Name	lblExitProgram
	Caption	Type "exit" to end program.
Label2	Name	lblCommand
	Caption	Command
Label3	Name	lblResponse
	Caption	Response
Text1	Name	txtCommand
	Text	<blank>
Text2	Name	txtResponse
	Text	<blank>
Command1	Name	cmdSend
	Caption	Send
	Default	True
Form1	Name	frmSerial
	Caption	Serial Interface Program
Timer1	Enabled	False
	Interval	10

12. Add code (provided in Table 4-3).
    a. In the Code Editor window, under the Object dropdown list, select (General). Add the statement: Public gSend as Boolean
    b. Double Click on cmdSend. Add code segment under Private Sub cmdSend_Click( ) as shown in Table 4-3.
    c. In the Code Editor window, under the Object dropdown list, select Form. Make sure the Procedure dropdown list is set at Load. The Code window should have written the segment of code: Private Sub Form_Load( ). Add the code to this subroutine as shown in Table 4-3.
    d. Double Click on the Timer control. Add code segment under Private Sub Timer1_Timer() as shown in Table 4-3.
    e. Make adjustments to code if different Com port settings are being used.
13. Save the program.
14. Run the program. The program should resemble the following.
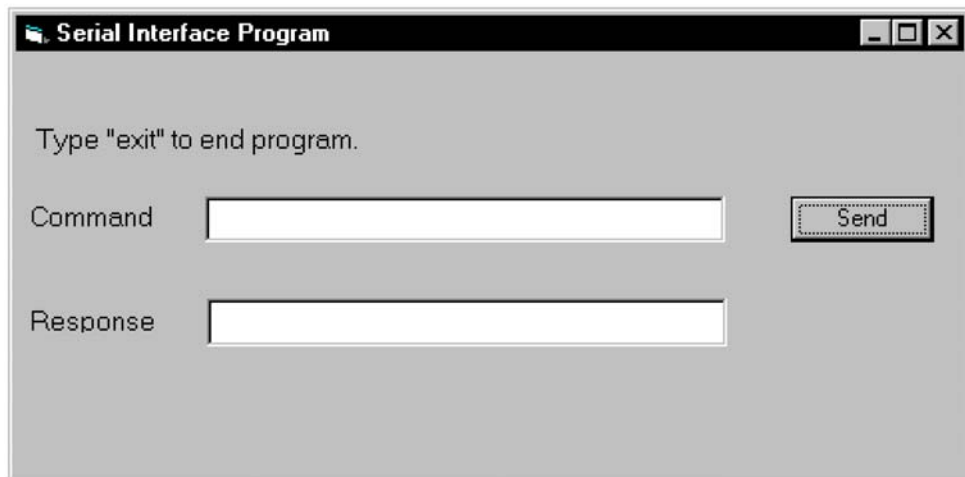
15. Type in a command or query in the Command box as described in Paragraph 4.1.7.3.
16. Press Enter or select the Send button with the mouse to send command.
17. Type Exit and press Enter to quit.

Table 4-3. Visual Basic Serial Interface Program

```
Public gSend As Boolean                              'Global used for Send button state

Private Sub cmdSend_Click()                           'Routine to handle Send button press
    gSend = True                                      'Set Flag to True
End Sub

Private Sub Form_Load()                               'Main code section
    Dim strReturn As String                           'Used to return response
    Dim strHold As String                             'Temporary character space
    Dim Term As String                                'Terminators
    Dim ZeroCount As Integer                          'Counter used for Timing out
    Dim strCommand As String                          'Data string sent to instrument

    frmSerial.Show                                    'Show main window
    Term = Chr(13) & Chr(10)                          'Terminators are <CR><LF>
    ZeroCount = 0                                     'Initialize counter
    strReturn = ""                                    'Clear return string
    strHold = ""                                      'Clear holding string
    If frmSerial.MSComm1.PortOpen = True Then         'Close serial port to change settings
        frmSerial.MSComm1.PortOpen = False
    End If
    frmSerial.MSComm1.CommPort = 1                    'Example of Comm 1
    frmSerial.MSComm1.Settings = "9600,o,7,1"         'Example of 9600 Baud,Parity,Data,Stop
    frmSerial.MSComm1.InputLen = 1                    'Read one character at a time
    frmSerial.MSComm1.PortOpen = True                 'Open port

  Do
    Do                                                'Wait loop
    DoEvents                                          'Give up processor to other events
    Loop Until gSend = True                           'Loop until Send button pressed
    gSend = False                                     'Set Flag as false

    strCommand = frmSerial.txtCommand.Text            'Get Command
    strReturn = ""                                    'Clear response display

    strCommand = UCase(strCommand)                    'Set all characters to upper case
    If strCommand = "EXIT" Then                       'Get out on EXIT
        End
    End If

    frmSerial.MSComm1.Output = strCommand & Term      'Send command to instrument
    If InStr(strCommand, "?") <> 0 Then               'Check to see if query
        While (ZeroCount < 20) And (strHold <> Chr$(10))  'Wait for response
            If frmSerial.MSComm1.InBufferCount = 0 Then   'Add 1 to timeout if no character
                frmSerial.Timer1.Enabled = True
                Do
                DoEvents                              'Wait for 10 millisecond timer
                Loop Until frmSerial.Timer1.Enabled = False
                ZeroCount = ZeroCount + 1             'Timeout at 2 seconds
            Else
                ZeroCount = 0                         'Reset timeout for each character
                strHold = frmSerial.MSComm1.Input     'Read in one character
                strReturn = strReturn + strHold       'Add next character to string
            End If
        Wend                                          'Get characters until terminators

        If strReturn <> "" Then                       'Check if string empty
            strReturn = Mid(strReturn, 1, InStr(strReturn, Term) - 1)  'Strip terminators
        Else
            strReturn = "No Response"                 'Send No Response
        End If
        frmSerial.txtResponse.Text = strReturn        'Put response in textbox on main form
        strHold = ""                                  'Reset holding string
        ZeroCount = 0                                 'Reset timeout counter
    End If
  Loop
End Sub

Private Sub Timer1_Timer()                            'Routine to handle Timer interrupt
    frmSerial.Timer1.Enabled = False                  'Turn off timer
End Sub
```

4.1.7.2   Quick Basic Serial Interface Program Setup

The serial interface program (Table 4-4) works with QuickBasic 4.0/4.5 or Qbasic on an IBM PC (or compatible) running DOS or in a DOS window with a serial interface. It uses the COM1 communication port at 9600 Baud. Use the following procedure to develop the Serial Interface Program in Quick Basic.

1. Start the Basic program.
2. Enter the program exactly as presented in Table 4-4.
3. Adjust the Com port and Baud rate in the program as necessary.
4. Lengthen the "TIMEOUT" count if necessary.
5. Save the program.
6. Run the program.
7. Type a command query as described in Paragraph 4.1.7.3.
8. Type "EXIT" to quit the program.

Table 4-4. Quick Basic Serial Interface Program

```
      CLS                                            'Clear screen
      PRINT " SERIAL COMMUNICATION PROGRAM"
      PRINT
      TIMEOUT = 2000                                 'Read timeout (may need more)
      BAUD$ = "9600"
      TERM$ = CHR$(13) + CHR$(10)                    'Terminators are <CR><LF>
      OPEN "COM1:" + BAUD$ + ",O,7,1,RS" FOR RANDOM AS #1 LEN = 256

LOOP1: LINE INPUT "ENTER COMMAND (or EXIT):"; CMD$   'Get command from keyboard
      CMD$ = UCASE$(CMD$)                            'Change input to upper case
         IF CMD$ = "EXIT" THEN CLOSE #1: END         'Get out on Exit
      CMD$ = CMD$ + TERM$
      PRINT #1, CMD$;                                'Send command to instrument

      IF INSTR(CMD$, "?") <> 0 THEN                  'Test for query
         RS$ = ""                                    'If query, read response
         N = 0                                       'Clr return string and count

         WHILE (N < TIMEOUT) AND (INSTR(RS$, TERM$) = 0)    'Wait for response
           IN$ = INPUT$(LOC(1), #1)                  'Get one character at a time
           IF IN$ = "" THEN N = N + 1 ELSE N = 0     'Add 1 to timeout if no chr
           RS$ = RS$ + IN$                           'Add next chr to string
         WEND                                        'Get chrs until terminators

         IF RS$ <> "" THEN                           'See if return string is empty
           RS$ = MID$(RS$, 1, (INSTR(RS$, TERM$) - 1))'Strip off terminators
           PRINT "RESPONSE:"; RS$                    'Print response to query
         ELSE
           PRINT "NO RESPONSE"                        'No response to query
         END IF
      END IF                                         'Get next command
      GOTO LOOP1
```

4.1.7.3 Program Operation

Once either program is running, try the following commands and observe the response of the instrument. Input from the user is shown in **bold** and terminators are added by the program. The word [term] indicates the required terminators included with the response.

```
ENTER COMMAND? *IDN?
```
Identification query. Instrument will return a string identifying itself.
```
RESPONSE: LSCI,MODEL421,0,070199[term]
```

```
ENTER COMMAND? FIELD?
```
Field reading query. Instrument will return a string with the present field reading.
```
RESPONSE: +12.345[term]
```

```
ENTER COMMAND? FIELDM?
```
Field multiplier query. Instrument will return a string with the field units multiplier. Blank indicated gauss, k indicates kilo gauss, etc.
```
RESPONSE: k[term]
```

```
ENTER COMMAND? RANGE 0
```
Range command. Instrument will change the field range to the highest setting. No response will be sent.

```
ENTER COMMAND? RANGE?
```
Range query. Instrument will return a string with the present range setting.
```
RESPONSE: 0[term]
```

```
ENTER COMMAND? RANGE 0;RANGE?
```
Range command followed by range query. Instrument will change range to highest setting then return a string with the present range setting.
```
RESPONSE: 0[term]
```

The following are additional notes on using either Serial Interface program.

- If you enter a correctly spelled query without a "**?**," nothing will be returned. Incorrectly spelled commands and queries are ignored. Commands and queries and should have a space separating the command and associated parameters.
- Leading zeros and zeros following a decimal point are not needed in a command string, but they will be sent in response to a query. A leading "**+**" is not required but a leading "**–**" *is* required.

4.1.8 Trouble Shooting

New Installation

1. Check instrument baud rate
2. Make sure transmit (TD) signal line from the instrument is routed to receive (RD) on the computer and vice versa. (Use a null modem adapter if not).
3. Always send terminators
4. Send entire message string at one time including terminators. (Many terminal emulation programs do not.)
5. Send only one simple command at a time until communication is established.
6. Be sure to spell commands correctly and use proper syntax.

Old Installation No Longer Working

1. Power instrument off then on again to see if it is a soft failure.
2. Power computer off then on again to see if communication port is locked up.
3. Verify that baud rate has not been changed on the instrument during a memory reset.
4. Check all cable connections.

Intermittent Lockups

1. Check cable connections and length.
2. Increase delay between all commands to 100 ms to make sure instrument is not being over loaded.

4.2 SERIAL INTERFACE COMMAND SUMMARY

This paragraph provides a summary of the Serial Interface Commands. The summary is divided into two command groups: Interface Commands and Device Specific Commands. Interface Commands are detailed in Paragraph 4.2.1. Device specific commands are detailed in Paragraph 4.2.2. A list of all commands is provided in Table 4-5.

Command Name — Brief Description of Function

ALMH? High Alarm Setpoint Query
Syntax of what user must input → **Input:** `ALMH?[term]`
Information returned in response to the query → **Returned:** <field value>[term]
Response format – see Key below → **Format:** nnn.nn (Refer to command for description)
Remarks as appropriate → **Remarks:** Use ALMHM? to determine units multiplier.

Key:

∗	Begins common interface command.
?	Required to identify queries.
aa…	String of alpha numeric characters.
nn…	String of number characters.
[term]	Terminator characters.
<…>	Indicated a parameter field, many are command specific.
<state>	Parameter field with only On/Off or Enable/Disable states.
<field value>	Field values have the range and resolution of displayed field readings. Field queries must be used with associated multiplier and units queries to obtain a complete field reading. Spaces will be returned in place of unused digits.
<multiplier>	µ = micro = 10^{-6}, m = milli = 10^{-3}, (blank) = unity, k = kilo = 10^{3}.

Table 4-5. Serial Interface Commands

* These commands are only available over the computer interface, i.e., there are no front panel equivalent commands: ✱IDN, SNUM, and TYPE.

4.2.1 Interface Commands

✱IDN?

Identification Query

Input: ✱**IDN?[term]**

Returned: <manufacturer>,<model>,0,<date>[term]

Format: aaaa,aaaaaaaa,n,mmddyy

<manufacture>	Manufacturer ID
<model>	Instrument model number
0	Indicates no serial number included
<date>	Instrument firmware revision date

Example: **LSCI,MODEL421,0,070199**

✱RST

Reset Command

Input: ✱**RST[term]**

Remarks: This command resets the instrument to its power up state. Similar to turning the power off and back on again.

BAUD

Set Serial Interface Baud Rate

Input: **BAUD <baud>[term]**

Format: n

<baud> 0 = 300, 1 = 1200, and 2 = 9600 baud

BAUD?

Serial Interface Baud Rate Query

Input: **BAUD?[term]**

Returned: <baud>[term]

Format: n (Refer to command for description)

4.2.2   Device Specific Commands

ACDC   AC or DC Field Measurement Command

Input: `ACDC <mode>[term]`

Format: n

                                                  <mode>   0 = DC, 1 = AC. Refer to Paragraph 3.3.

ACDC?   AC or DC Field Measurement Query

Input: `ACDC?[term]`

Returned: <mode>[term]

Format: n   (Refer to command for description)

ALARM   Alarm On/Off Command

Input: `ALARM <state>[term]`

Format: n

                                                  <state>   0 = Off, 1 = On. Refer to Paragraph 3.9.

ALARM?   Alarm On/Off Query

Input: `ALARM?[term]`

Returned: <state>[term]

Format: n   (Refer to command for description)

ALMB   Audible Alarm Beeper Enable/Disable Command

Input: `ALMB <state>[term]`

Format: n

                                                  <state>   0 = Disabled, 1 = Enabled

---

ALMB?   Audible Alarm Beeper Enable/Disable Query

Input: `ALMB?[term]`

Returned: <state>[term]

Format: n   (Refer to command for description)

ALMH   High Alarm Setpoint Command

Input: `ALMH <field value>[term]`

Format: ±nnn.nn

                            <field value>   Enter sign, 4 or 5 digits, and place decimal point appropriate to range.

Remarks: New value is entered on the same field range as the old value. Setting value to zero first will change the setting range to present display range.

Device Specific Commands (Continued)

ALMH?   High Alarm Setpoint Query

Input: `ALMH?[term]`

Returned: <field value>[term]

Format: ±nnn.nn   (Refer to command for description)

Remarks: Use ALMHM? to determine units multiplier.

ALMHM?   High Alarm Setpoint Multiplier Query

Input: `ALMHM?[term]`

Returned: <multiplier>[term]

Format: a

<multiplier>   µ = micro = 10^{-6}, m = milli = 10^{-3}, (blank) = unity, k = kilo = 10^{3}

Remarks: Used with ALMH? query.

ALMIO   Alarm Inside/Outside Command

Input: `ALMIO <inout>[term]`

Format: n

<inout>   0 = Outside or 1 = Inside

Remarks: Instructs alarm feature to cause an active alarm state when the field reading is either inside of or outside of the high and low setpoint values. Refer to Paragraph 3.9.

ALMIO?   Alarm Inside/Outside Query

Input: `ALMIO?[term]`

Returned: <inout>[term]

Format: n   (Refer to command for description)

ALML   Low Alarm Setpoint Command

Input: `ALML <field value>[term]`

Format: ±nnn.nn

<field value>   Enter sign, 4 or 5 digits, and place decimal point appropriate to range.

Remarks: New value is entered on the same field range as the old value. Setting value to zero first will change the setting range to present display range.

ALML?   Low Alarm Setpoint Query

Input: `ALML?[term]`

Returned: <field value>[term]

Format: ±nnn.nn   (Refer to command for description)

Remarks: Use ALMLM? to determine units multiplier.

Device Specific Commands (Continued)

ALMLM? Low Alarm Setpoint Multiplier Query

Input: `ALMLM?[term]`

Returned: <multiplier>[term]

Format: a

<multiplier> μ = micro = 10^{-6}, m = milli = 10^{-3}, (blank) = unity, k = kilo = 10^{3}

Remarks: Used with ALML? query.

ALMS? Alarm Status Query

Input: `ALMS?[term]`

Returned: <state>[term]

Format: n

<state>   0 = alarm in normal state, 1 = alarm active

Remarks: Either a high or a low alarm can cause an active alarm status.

ALMSORT Sort Pass/Fail Command

Input: `ALMSORT <state>[term]`

Format: n

<state>   0 = Off, 1 = On

ALMSORT? Sort Pass/Fail Query

Input: `ALMSORT?[term]`

Returned: <state>[term]

Format: n   (Refer to command for description)

AUTO Auto Range Command

Input: `AUTO <state>[term]`

Format: n

<state>   0 = Auto Range Off, 1 = Auto Range On. Refer to Paragraph 3.5.

AUTO? Auto Range Query

Input: `AUTO?[term]`

Returned: <state>[term]

Format: n   (Refer to command for description)

BRIGT Front Panel Display Brightness Command

Input: `BRIGT <brightness>[term]`

Format: n

<brightness>   0 or 1 = first setting (dimmest), 2 or 3 = second setting, 4 or 5 = third setting, 6 or 7 fourth setting (brightest). Default setting is 4. Refer to Paragraph 3.14.

Device Specific Commands (Continued)

BRIGT? Front Panel Display Brightness Query

Input: `BRIGT?[term]`

Returned: <brightness>[term]

Format: n   (Refer to command for description)

FAST Fast Data Mode Command

Input: `FAST <state>[term]`

Format: n

<state>   0 = Off, 1 = On

Remarks: Fast Data Mode reaches data rates up to 18 readings per second via the Serial Interface with a corresponding increase in corrected analog output. The front panel display does not function in this mode. Refer to Paragraph 3.12.

FAST? Fast Data Mode Query

Input: `FAST?[term]`

Returned: <state>[term]

Format: n   (Refer to command for description)

FIELD? Magnetic Field Reading Query

Input: `FIELD?[term]`

Returned: <field value>[term]

Format: ±nnn.nn

<field value>   Returns sign, 4 or 5 digits, and places decimal point appropriate to range.

Remarks: Use FIELDM? to determine units multiplier and UNITS? to determine gauss or tesla units.

FIELDM? Field Reading Multiplier Query

Input: `FIELDM?[term]`

Returned: <multiplier>[term]

Format: a

<multiplier> μ = micro = 10^{-6}, m = milli = 10^{-3}, (blank) = unity, k = kilo = 10^{3}

Remarks: Used with FIELD? query.

FILT Display Filter Command

Input: `FILT <state>[term]`

Format: n

<state>   0 = Off, 1 = On

Remarks: Quiets the display reading. Refer to Paragraph 3.4.

FILT? Display Filter Query

Input: `FILT?[term]`

Returned: <state>[term]

Format: n   (Refer to command for description)

Device Specific Commands (Continued)

LOCK Front Panel Keypad Lock Command

Input: `LOCK <state>[term]`

Format: n

                                     <state>   0 = Unlocked, 1 = Locked

Remarks: Locks out all front panel entries except pressing the **Alarm** key to silence alarms. Refer to Paragraph 3.13.

LOCK? Front Panel Keypad Lock Query

Input: `LOCK?[term]`

Returned: <state>[term]

Format: n   (Refer to command for description)

MAX Max Hold Command

Input: `MAX <state>[term]`

Format: n

                                       <state>   0 = Off, 1 = On

Remarks: Works with the MAXR and MAXC commands. Refer to Paragraph 3.7.

MAX? Max Hold Query

Input: `MAX?[term]`

Returned: <state>[term]

Format: n   (Refer to command for description)

MAXC Max Reset Command

Input: `MAXC[term]`

Remarks: This command initiates a Max Reset. Upon entry, the Max Hold function is zeroed out and a new peak is captured. Refer to Paragraph 3.7.

MAXR? Max Reading Query

Input: `MAXR?[term]`

Returned: <field value>[term]

Format: +nnn.nn

                                       <field value>   Returns plus (+) sign, 4 or 5 digits, and places decimal point appropriate to range.

Remarks: Use MAXRM? to determine units multiplier and UNITS? to determine gauss or tesla units.

MAXRM? Max Reading Multiplier Query

Input: `MAXRM?[term]`

Returned: <multiplier>[term]

Format: a

                                       <multiplier> μ = micro = 10^{-6}, m = milli = 10^{-3}, (blank) = unity, k = kilo = 10^{3}

Remarks: Used with MAXR? query.

Device Specific Commands (Continued)

RANGE   Manual Range Command

Input: `RANGE <range>[term]`

Format: n

                       <range>   0 = first range (highest) , 1 = second range, 2 = third range, 3 = fourth range (lowest)

Remarks: Range depends on type of probe installed. There are four ranges possible for each probe. Refer to Paragraph 3.5.

RANGE?   Manual Range Query

Input: `RANGE?[term]`

Returned: <range>[term]

Format: n   (Refer to command for description)

REL   Relative Mode Command

Input: `REL <state>[term]`

Format: n

                       <state>   0 = Off, 1 = On

Remarks: Works with the RELR(?), RELRM(?), RELS(?), and RELSM(?) commands. Remote operation is slightly different from front panel operation described in Paragraph 3.8. From the front panel, the current reading is captured as the setpoint when Relative is turned on. However, when activated by remote command, the initial relative setpoint is zero. The RELS command is used to enter a setpoint.

REL?   Relative Mode Query

Input: `REL?[term]`

Returned: <state>[term]

Format: n   (Refer to command for description)

RELR?   Relative Mode Reading Query

Input: `RELR?[term]`

Returned: <field value>[term]

Format: ±nnn.nn

                       <field value>   Returns sign, 4 or 5 digits, and places decimal point appropriate to range.

Remarks: Use RELRM? to determine units multiplier and UNITS? to determine gauss or tesla units.

RELRM?   Relative Mode Reading Multiplier Query

Input: `RELRM?`

Returned: <multiplier>[term]

Format: a

                       <multiplier> μ = micro = 10^{-6}, m = milli = 10^{-3}, (blank) = unity, k = kilo = 10^{3}

Remarks: Used with RELR? query.

Device Specific Commands (Continued)

RELS Relative Mode Setpoint Command
Input: `RELS <setpoint>[term]`
Format: nnn.nn
<setpoint> Relative mode setpoint value with up to 5 digits resolution.
Remarks: New value is entered on the same field range as the old value. Setting value to zero first will change the setting range to present display range.

RELS? Relative Mode Setpoint Query
Input: `RELS?[term]`
Returned: <setpoint>[term]
Format: nnn.nn (Refer to command for description)
Remarks: Use RELSM? to determine units multiplier.

RELSM? Relative Mode Setpoint Multiplier Query
Input: `RELSM?[term]`
Returned: <multiplier>[term]
Format: a
<multiplier> μ = micro = 10^{-6}, m = milli = 10^{-3}, (blank) = unity, k = kilo = 10^{3}
Remarks: Used with RELS? query.

SNUM? Probe Serial Number Query
Input: `SNUM?[term]`
Returned: <serial>[term]
Format: annnnnnnnn
<serial> The current probe serial number format is Hnnnnn, though there is room for up to a ten-character response.

TYPE? Probe Type Query
Input: `TYPE?[term]`
Returned: <probe>[term]
Format: n
<probe> 0 = High Sensitivity (HSE), 1 = High Stability (HST), 2 = Ultra-High Sensitivity (UHS)

Device Specific Commands (Continued)

UNIT   Gauss or Tesla Unit Command

Input: `UNIT <unit>[term]`

Format: a

                  <unit>   G = gauss, T = tesla. Refer to Paragraph 3.2.

UNIT?   Gauss or Tesla Unit Query

Input: `UNIT?[term]`

Returned: <unit>[term]

Format: a   (Refer to command for description)

ZCAL   Zero Probe Command

Input: `ZCAL[term]`

Remarks: This command initiates the Zero Probe function. Place probe in the Zero Gauss Chamber first and then enter the ZCAL command. Refer to Paragraph 3.6.

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CHAPTER 5

ACCESSORIES AND PROBES

5.0 GENERAL

This chapter provides lists of Model 421 Gaussmeter accessories and probes. Accessories are described in Paragraph 5.1. Probes are described in Paragraph 5.2. Helmholtz coils are described in Paragraph 5.3. Finally, reference magnets are described in Paragraph 5.4.

5.1 ACCESSORIES

Accessories are devices that perform a secondary duty as an aid or refinement to the primary unit. A list of accessories available for the Model 421 are as follows:

Model	Description of Accessory
106-741	**Terminal Block Mating Connector**. One 3-pin connector for Alarm Relay. See Figure 6-4.
4030-XX	**Hall Probe Stand**. This moveable probe stand consists of a 30 mm square post mounted on a 180 × 130 × 22.5 mm thick base plate. A probe holder is integrated into the stand. The holder can be moved up or down and fixed at any angle and location along the post. Two models are available as follows. Consult factory for other post heights. **4030-12** Hall probe stand with 12 inch tall post and probe holder to accept 3/8 inch diameter Hall probe handle. **4030-24** Hall probe stand with 24 inch tall post and probe holder to accept 3/8 inch diameter Hall probe handle.
4060	**Standard Zero Gauss Chamber.** Used for standard probe field nulling. Size: 32 × 32 × 61 mm (1.3 × 1.3 × 2.4 inches). Bore: 12 mm diameter × 51 mm deep (0.5 × 2 inches). See Figure 5-12.
4065	**Large Zero Gauss Chamber.** Used for Gamma Probe™ field nulling. Size: 57 × 53 × 305 mm (2.3 × 2.1 × 12 inches). Bore: 19 mm diameter × 279 mm deep (0.8 × 11 inches). See Figure 5-13.
MAN-421	**Model 421 Gaussmeter User's Manual.**
MCBL-XX	**Hall Generator Cable Assembly**. The MCBL Cable Assembly connects a discrete Hall generator to the Model 421 Gaussmeter. The cable ships with the HALLCAL.EXE program which permits cable PROM programming through a PC (or compatible) computer serial port. Because of the many calibration intricacies, the user is responsible for measurement accuracy. Refer to Appendix C. **MCBL-6** Hall Generator Cable Assembly – 2 meters (6 feet) long **MCBL-20** Hall Generator Cable Assembly – 6 meters (20 feet) long

Accessories (Continued)

MODEL NUMBER	DESCRIPTION OF ACCESSORY
MH-XX	**Helmholtz Coils**. Provides stable low magnetic field when used with customer-supplied power supply. Often used to provide reference field to help check gaussmeter accuracy. Three coils are available as follows. Refer to Paragraph 5.3. **MH-2.5** Helmholtz Coil, 2.5-inch inner diameter, field strength: ≈30 G @ 1 A, maximum continuous current: 2 A, coil resistance: ≈3 Ω. See Figure 5-8. **MH-6** Helmholtz Coil, 6-inch inner diameter, field strength: ≈50 G @ 2 A, maximum continuous current: 2 A, Coil Resistance: ≈10 Ω. See Figure 5-9. **MH-12** Helmholtz Coil. 12-inch inner diameter, field strength: ≈25 G @ 1 A, maximum continuous current: 2 A, Coil Resistance: ≈20 Ω. See Figure 5-10.
MRA-XXX MRT-XXX	**Reference Magnets**. High-quality reference magnets are available in transverse (flat) and axial (round) configurations. Refer to Paragraph 5.4 and see Figure 5-11. **MRA-312-100** Axial Reference Magnet: 0.312" inside diameter, 100 G, 1% **MRA-312-200** Axial Reference Magnet: 0.312" inside diameter, 200 G, 1% **MRA-312-300** Axial Reference Magnet: 0.312" inside diameter, 300 G, 1% **MRA-312-500** Axial Reference Magnet: 0.312" inside diameter, 500 G, 1% **MRA-312-1K** Axial Reference Magnet: 0.312" inside diameter, 1 kG, 1% **MRA-312-2K** Axial Reference Magnet: 0.312" inside diameter, 2 kG, 1% **MRT-062-200** Transverse Reference Magnet: 0.062" gap, 200 G, 1% **MRT-062-500** Transverse Reference Magnet: 0.062" gap, 500 G, 1% **MRT-062-1K** Transverse Reference Magnet: 0.062" gap, 1 kG, 0.5% **MRT-062-2K** Transverse Reference Magnet: 0.062" gap, 2 kG, 0.5% **MRT-062-5K** Transverse Reference Magnet: 0.062" gap, 5 kG, 0.5% **MRT-062-10K** Transverse Reference Magnet: 0.062" gap, 10 kG, 5% **MRT-343-50** Transverse Reference Magnet: 0.343" gap, 50 G, 1% **MRT-343-100** Transverse Reference Magnet: 0.343" gap, 100 G, 1%
MPEC-XXX	**Probe Extension Cables**. Four cables are available. Each extension cable contains a EEPROM for calibration data. Each extension cable must be matched to a specific probe. To maintain probe accuracy, that probe and extension cable must be calibrated together at Lake Shore. The probe will exhibit its full accuracy if used without the extension cable. Part numbers and cables lengths are defined as follows: **MPEC-10** Probe Extension Cable – 3 meters (10 feet) **MPEC-25** Probe Extension Cable – 7.6 meters (25 feet) **MPEC-50** Probe Extension Cable – 15.2 meters (50 feet) **MPEC-100** Probe Extension Cable – 30.5 meters (100 feet)
RM-1/2	**Half-Rack Mounting Kit for One Gaussmeter.** Half-length mounting panel and mounting ears to attach a Model 421 to a 483 mm (19-inch) rack mount space. See Figure 5-14.
RM-2	**Rack Mounting Shelf for Two Gaussmeters.** Mounting shelf to attach two Model 421 Gaussmeters to a 483 mm (19-inch) rack mount space. See Figure 5-15.

5.2 LAKE SHORE STANDARD PROBES

In addition to the probe included with the purchase, additional probes are available for use with the Model 421 Gaussmeter. Examples include Axial, Flexible Axial, Transverse, Flexible Transverse, Robust Transverse, Tangential, and the Gamma Probe. Because the Model 421 covers such a wide magnetic field range (0.01 mG to 300 kG), three probe ranges are available: High Stability (HST), High Sensitivity (HSE), and Ultra-High Sensitivity (UHS). Please consult the factory for availability of probe types not detailed in these figures. Information on Hall generators is presented in Appendix C.

5.2.1 Probe Selection Criteria

Some guidelines are provided below to aid in the selection of a probe for you application.

1. Choose a probe to match the application. Do not buy more accuracy, field range, or fragility than is actually necessary.
2. The thinner a probe, the more fragile it is. Try to avoid the temptation to select an easily damaged probe based on a possible, but not probable, future application. For instance, avoid using an exposed-device probe such as a Model MFT-3E03 or MNA-1904 type for general field measurements. *Once a stem or sensor has been damaged, the probe is not repairable.*
3. Metal enclosed probes, such as the Model MMT-6J08 and MMA-2508 types, offer the greatest amount of protection to the Hall sensor, and therefore are the most rugged types.
4. Be cautious about using aluminum stemmed, transverse probes, such as the Model MMT-6J08 type, where AC magnetic fields are to be measured. Eddy currents in the stem material can affect reading accuracy. A superior choice for AC measurements would b the Model MNT-4E04 type fiberglass-epoxy stem probes.
5. Several stem lengths are offered for each probe type. User preferences or test set-up dimensions usually determine the final selection. Longer stems are more susceptible to accidental bending (in many cases not catastrophic, but bothersome). Stem length does not affect performance.
6. Be aware of the differences in the probe "active areas" shown on the data sheet. A Hall effect probe will indicate the average field value sensed over that total active area. Thus, when measuring magnetic fields with a high gradient across the sensor width, choose the smallest active area practical (keeping in mind, however, the fragility rule in number 2 above).
7. Lake Shore gaussmeter probes exhibit different ranges of magnetic fields over which they will provide valid readings. Check the specification sheet for these usable ranges. High Stability probes, such as those whose model numbers end in -VG, are usable on full scale ranges of 300 gauss (30 millitesla) to 30 kilogauss (3 tesla). The High Sensitivity family of probes (i.e., -VH models) can be used on 30 G (3 mT) to 30 kG (3 T) full scale ranges. High field probes are specially calibrated to provide use above 30 kG (3 T), and the Gamma Probe operates on the 300 mG (30 µT) and 3 G (300 µT) ranges.
8. If none of the standard probe configurations seem to fit your needs, always remember that Lake Shore can provide custom probes to meet your physical, temperature, and accuracy requirements. Contact Lake Shore with details of your special requirements.

5.2.2 Radiation Effects on Gaussmeter Probes

The HST and HSE probes use a highly doped indium arsenide active material. The HST material is the more highly doped of the two and therefore will be less affected by radiation. Some general information relating to highly doped indium arsenide Hall generators is as follows:

*   Gamma radiation seems to have little effect on the Hall generators.
*   Proton radiation up to 10 Mrad causes sensitivity changes <0.5%.
*   Neutron cumulative radiation (>0.1 MeV, 10^{15}/sq. cm.) can cause a 3 to 5% decrease in sensitivity.
*   In all cases the radiation effects seem to saturate and diminish with length of time exposed.

5.2.3   Probe Specifications

Terminology used in Figures 5-1 thru 5-7 are defined as follows:

Definition of Probe Terminology
A = Distance from tip to center line of active area +B = Magnetic flux density vector (for + reading) HST = High Stability Probe HSE = High Sensitivity Probe UHS = Ultra-High Sensitivity Probe

Usable Full-Scale Ranges Vs. Probe Type				
Type	**HST-1**	**HST-2**	**HSE-1**	**UHS-1**
Usable on Ranges	300 G	300 G	30 G	300 mG
	3 kG	3 kG	300 G	3 G
	30 kG	30 kG	3 kG	30 G
	300 kG	—	30 kG	—

GAMMA PROBE
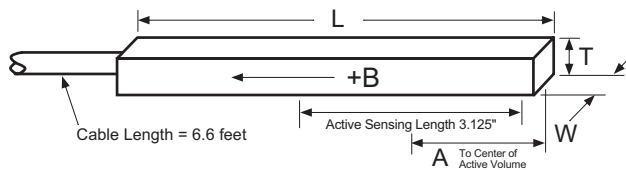
Small variations in, or low values of large volume magnetic fields, such as that of the Earth or fringe fields, around large solenoids, can be measured with these ultra-high sensitivity probes. Resolutions of several gammas (10^{-5} G) to tens of gammas are available depending on the mating gaussmeter. Application is optimum when fields are homogeneous over lengths greater than 1 foot. The active sensing length of the gamma probe is 3.125 inches.

Model No.	W	T	A	L	Frequency Range	Type	Corrected Accuracy (% of Reading)	Operating Temperature Range	Temperature Coefficient (Maximum)	
									Zero	Calibration
MLA-5006-HJ	0.25 ±0.03"	0.5"	2.2"	5.7"	DC, 10 to 400 Hz	UHS-1	±0.5% to 2 gauss	0 °C to +75 °C	1 mG/°C	±0.02%/°C

Gamma.eps

Figure 5-1. Definition of Lake Shore Gamma Probe

ROBUST (BRASS STEM) TRANSVERSE PROBES
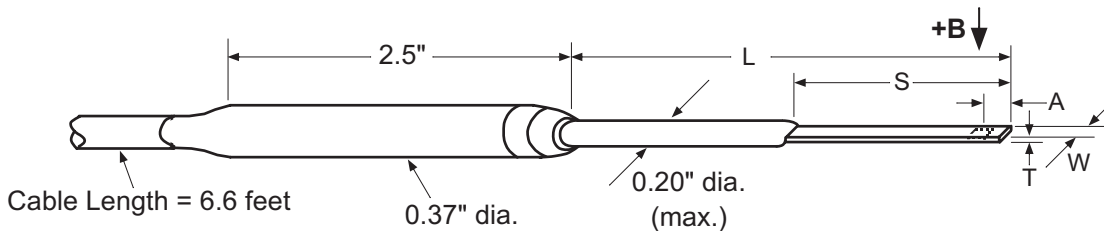
Model No.	L	S	W	T	A	Active Area	Stem Material	Frequency Range	Type	Corrected Accuracy (% of Reading)	Operating Temperature Range	Temperature Coefficient (maximum)	
												Zero	Calibration
MMTB-6J02-VH	2 ±0.125"	1.75"	0.22"	0.061" max	0.150"	0.040" dia. approx.	Brass	DC	HSE-1	±0.25% to 30 kG	0 °C to 75 °C	±0.09 G/°C	±0.015%/°C
MMTB-6J04-VH	4 ±0.125"	3.5" to 4"											
MMTB-6J08-VH	8 ±0.125"												
MMTB-6J02-VG	2 ±0.125"	1.75"							HST-2	±0.15% to 30 kG		±0.13 G/°C	−0.005%/°C
MMTB-6J04-VG	4 ±0.125"	3.5" to 4"											
MMTB-6J08-VG	8 ±0.125"												

Brass_Transverse.eps

Figure 5-2. Definition of Lake Shore Robust (Brass Stem) Transverse Probes

TRANSVERSE PROBES

Cable length = 6.6 feet   0.36 ±0.030" dia.

Model No.	L	T	W	A	Active Area	Stem Material	Freq. Range	Type	Corrected Accuracy (% of rdg)	Op. Temp. Range	Temperature Coefficient (Max.)	
											Zero	Calibration
MMT-6J02-VH	2 ±0.125"	0.061" max.	0.180 ±0.005"	0.150 ± 0.050"	0.040" dia. approx.	Alum.	DC	HSE-1	±0.25% to 30 kG	0 °C to +75 °C	±0.09 Gauss per °C	±0.015% per °C
MMT-6J04-VH*	4 ±0.125"											
MMT-6J08-VH	8 ±0.125"											
MMT-6J18-VH	18 ±0.25"											
MNT-4E02-VH	2 ±0.125"	0.045" max.	0.150 ±0.005"			Rigid Glass Epoxy	DC, 10 to 400 Hz					
MNT-4E04-VH*	4 ±0.125"											
MMT-6J02-VG	2 ±0.125"	0.061" max.	0.180 ±0.005"			Alum.	DC	HST-2	±0.15% to 30 kG		±0.13 Gauss per °C	−0.005% per °C
MMT-6J04-VG*	4 ±0.125"											
MMT-6J08-VG	8 ±0.125"											
MMT-6J18-VG	18 ±0.125"											
MNT-4E02-VG*	2 ±0.125"	0.045" max.	0.150 ±0.005"			Rigid Glass Epoxy	DC, 10 to 400 Hz					
MNT-4E04-VG	4 ±0.125"											
MCT-3160-WN	61 ±1"	0.25 dia. ±0.010"		0.210 ±0.050"		Stainless Steel		HST-1	±2% to 100 kG	1.5 K to 350 K		±0.010% per °C

* One probe is included with the purchase of the Model 421. Model numbers shown in **bold** are the probes available to choose from.

Transverse.eps

Figure 5-3. Definition of Lake Shore Transverse Probes

TANGENTIAL PROBE

Cable length = 6.6 feet   0.36 ±0.030" dia.

Model No.	L	T	W	A	Active Area	Stem Material	Freq. Range	Type	Corrected Accuracy (% of rdg)	Op. Temp. Range	Temperature Coefficient (Max.)	
											Zero	Calibration
MNTAN-DQ02-TH	1.5" ±0.125"	0.125" max.	0.38" max.	0.030" ±0.005"	0.020" dia. approx.	Plastic	DC, 10 to 400 Hz	HSE-1	±0.25% to 20 kG	0 °C to +75 °C	±0.1 G/°C	−0.05%/°C

Tangential.eps

Figure 5-4. Definition of Lake Shore Tangential Probe

AXIAL PROBES

2.5" — L — A
Cable Length = 6.6 feet   0.36 ±0.030" dia.   D   +B
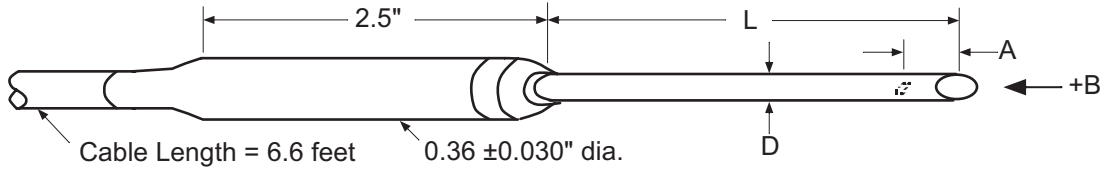
Model	L	D	A	Active Area	Stem Material	Freq. Range	Type	Corrected Accuracy (% Reading)	Op. Temp. Range	Temp. Coefficient (Max.) Zero	Temp. Coefficient (Max.) Calibration
MMA-0602-TH	2 ±0.125"	0.060 dia. +0.001 -0.003"	0.005 ± 0.003"	0.020" dia. approx.	Alum.	DC, 10 to 400 Hz	HST-2	±0.25% to 10 kG		±0.13 G per °C	±0.01% per °C
MMA-0604-TH	4 ±0.125"										
MMA-0608-TH	8 ±0.125"										
MMA-0618-TH	18 ±0.125"										
MMA-0802-UH	2 ±0.125"	0.080" dia. ±0.005"	0.010"			DC		±0.25% to 20 kG			
MMA-0804-UH	4 ±0.125"										
MMA-0808-UH	8 ±0.125"										
MNA-1902-VH	2 ±0.125"	0.187 dia. ±0.005"	0.005 ± 0.003"	0.030" dia. approx.	Fiberglass Epoxy	DC, 10 to 400 Hz	HSE-1	±0.25% to 30 kG	0 °C to 75 °C	±0.09 G per °C	±0.015% per °C
MNA-1904-VH*	4 ±0.125"										
MNA-1908-VH	8 ±0.125"										
MMA-1802-VH	2 ±0.063"	0.180 dia. +0.002 -0.004"	0.016 ± 0.005"		Alum.						
MMA-1808-VH	8 ±0.125"										
MMA-1818-VH	18 ±0.25"										
MMA-1836-VH	36 ±0.25"										
MMA-2502-VH*	2 ±0.063"	0.25 dia. ±0.006"									
MMA-2508-VH	8 ±0.125"										
MNA-1902-VG	2 ±0.125"	0.187 dia. ±0.005"			Fiberglass Epoxy		HST-2	0.15% to 30 kG		±0.13 G per °C	–0.005% per °C
MNA-1904-VG*	4 ±0.125"										
MNA-1908-VG	8 ±0.125"										
MMA-1802-VG	2 ±0.063"	0.180 dia. +0.002 –0.004"	0.016 ± 0.005"		Alum.						
MMA-1808-VG	8 ±0.125"										
MMA-1818-VG	18 ±0.25"										
MMA-1836-VG	36 ±0.25"										
MMA-2502-VG*	2 ±0.063"	0.25 dia. ±0.006"									
MMA-2508-VG	8 ±0.125"										
MMA-1808-WL	8 ±0.125"	0.180 dia. +0.002 –0.004"					HST-1	±1% to 100 kG			
MMA-2536-WL	36 ±0.25"	0.25 dia. ±0.006"				DC					
MCA-2560-WN	60 ±0.50"	0.25 dia. ±0.005"	0.025 ±0.005"		Stainless Steel			±2% to 100 kG	1.5 K to 350 K		±0.010% per °C

* One probe is included with the purchase of the Model 421. Model numbers shown in **bold** are the probes available to choose from.

Axial.eps

Figure 5-5. Definition of Lake Shore Axial Probes

FLEXIBLE TRANSVERSE PROBES
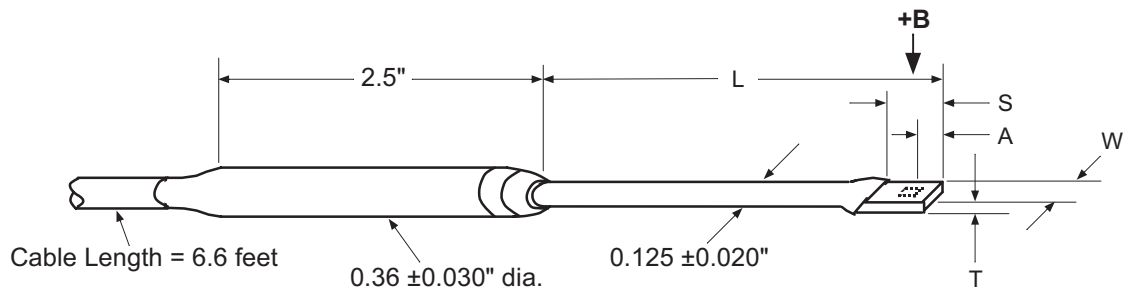
This table is for L = 3 inches and S = 0.375 inch

Model No.	W	T	A	Active Area	Stem Material	Frequency Range	Type	Corrected Accuracy (% of Reading)	Operating Temperature Range	Temperature Coefficient (maximum)	
										Zero	Calibration
MFT-3E03-VH	0.135" max	0.025" max	0.125" ±0.005"	0.040" dia. approx.	Flexible Tubing	DC, 10 to 400 Hz	HSE-1	±0.25% to 30 kG	0 °C to 75 °C	±0.09 G/°C	±0.015%/°C
MFT-3E03-VG							HST-2	±0.15% to 30 kG		±0.13 G/°C	−0.005%/°C
MFT-2903-VJ	0.085" max	0.020" max	0.065" ±0.005"	0.030" dia. approx.			HSE-1	±0.50% to 30 kG		±0.09 G/°C	±0.015%/°C
MFT-2903-VH							HST-2	±0.25% to 30 kG		±0.13 G/°C	−0.005%/°C

This table is for L = 15 ±0.5 inches and S = 0.75 inch

MFT-4F15-VH	0.150" ±0.005"	0.045" max	0.150" ±0.050"	0.040" dia. approx.	Flexible Tubing & Epoxy Fiber-glass	DC, 10 to 400 Hz	HSE-1	±0.25% to 30 kG	0 °C to 75 °C	±0.09 G/°C	±0.015%/°C
MFT-4F15-VG							HST-2	±0.15% to 30 kG		±0.13 G/°C	−0.005%/°C

Flexible_Transverse.eps

Figure 5-6. Definition of Lake Shore Flexible Transverse Probes

FLEXIBLE AXIAL PROBE
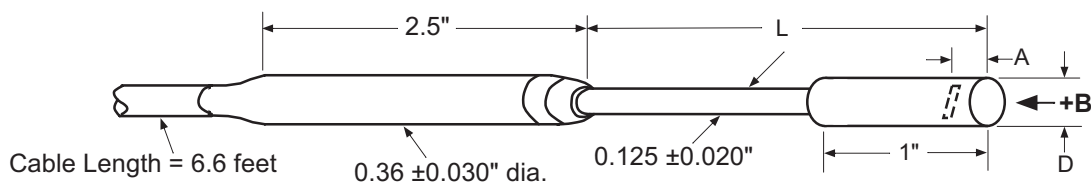
Model No.	L	D	A	Active Area	Stem Material	Frequency Range	Type	Corrected Accuracy (% of Reading)	Operating Temperature Range	Temperature Coefficient (max.)	
										Zero	Calibration
MFA-1815-VH	15" ±0.5"	0.025" max	0.125" ±0.005"	0.040" dia. approx.	Flexible Tubing	DC, 10 to 400 Hz	HSE-1	±0.25% to 30 kG	0 °C to 75 °C	±0.09 G/°C	±0.015%/°C

Flexible_Axial.eps

Figure 5-7. Definition of Lake Shore Flexible Axial Probe

5.3 HELMHOLTZ COIL LOW FIELD STANDARDS

Lake Shore offers three Helmholtz coils: 2.5-, 6-, and 12-inch diameter. Check the latest Lake Shore brochures or our website for any recent additions to this line.

These coils are accurately calibrated using field standards maintained at Lake Shore. Most standards are traceable to physical standards such as a coil of carefully controlled dimensions, or in some cases, to proton resonance. The field strengths are measured on the basis of the field generated by a current through the coil.

When combined with a customer-supplied power supply, these coils can be used as low-field reference magnets to compliment our set of standard reference magnets (defined in Paragraph 5.4). The power supply must be capable of 2 A output and a constant-current mode is recommended.

	MH-2.5	MH-6	MH-12
Inside Diameter	2.5 inches	6 inches	12 inches
Field Accuracy	±0.5%		
Field Strength	≈30 G @ 1 A	≈25 G @ 1 A	≈12 G @ 1 A
Field Homogeneity	0.5% within a cylindrical volume 0.75" long, 0.75" diameter, located at center of coil	0.5% within a cylindrical volume 1.6" long, 1.6" diameter, located at center of coil	0.5% within a cylindrical volume 3.2" long, 3.2" diameter, located at center of coil
Coil Resistance/Inductance	≈3 Ω / 6.3 mH	≈10 Ω / 36 mH	≈20 Ω / 93 mH
Maximum Continuous Current	2 A DC or AC RMS		
Operating Temperature Range	10 to 40 °C (50 to 104 °F)		
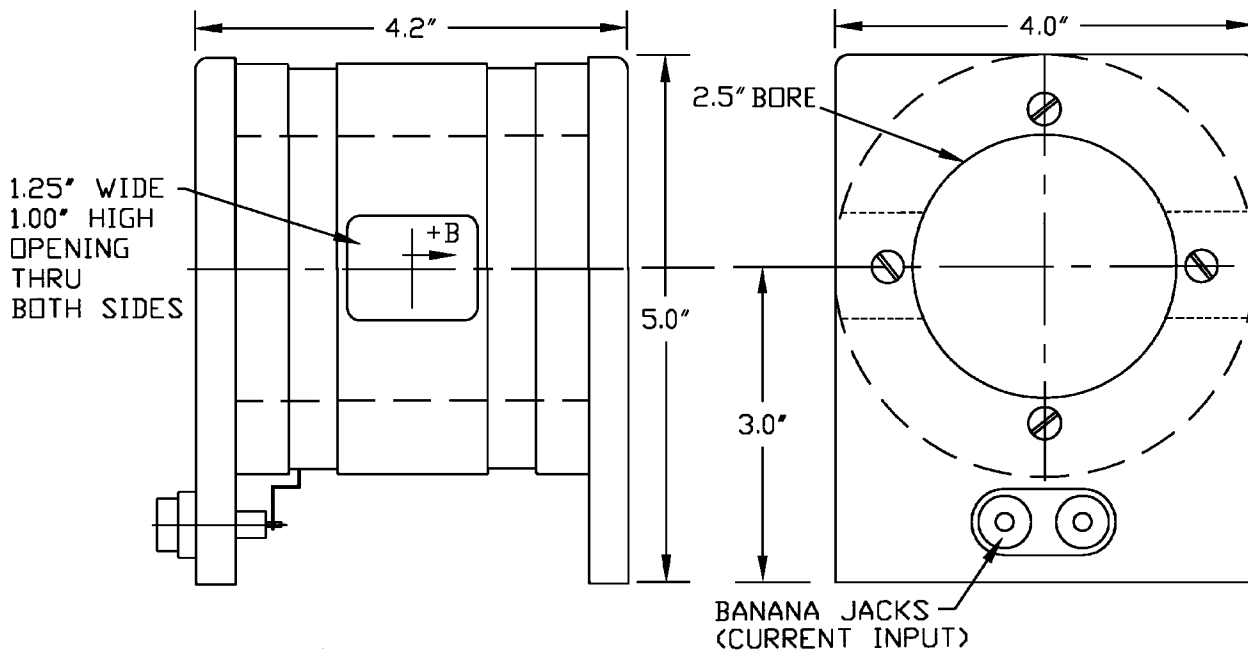
P-421-5-08.bmp

Figure 5-8. Model MH-2.5 Helmholtz Coil
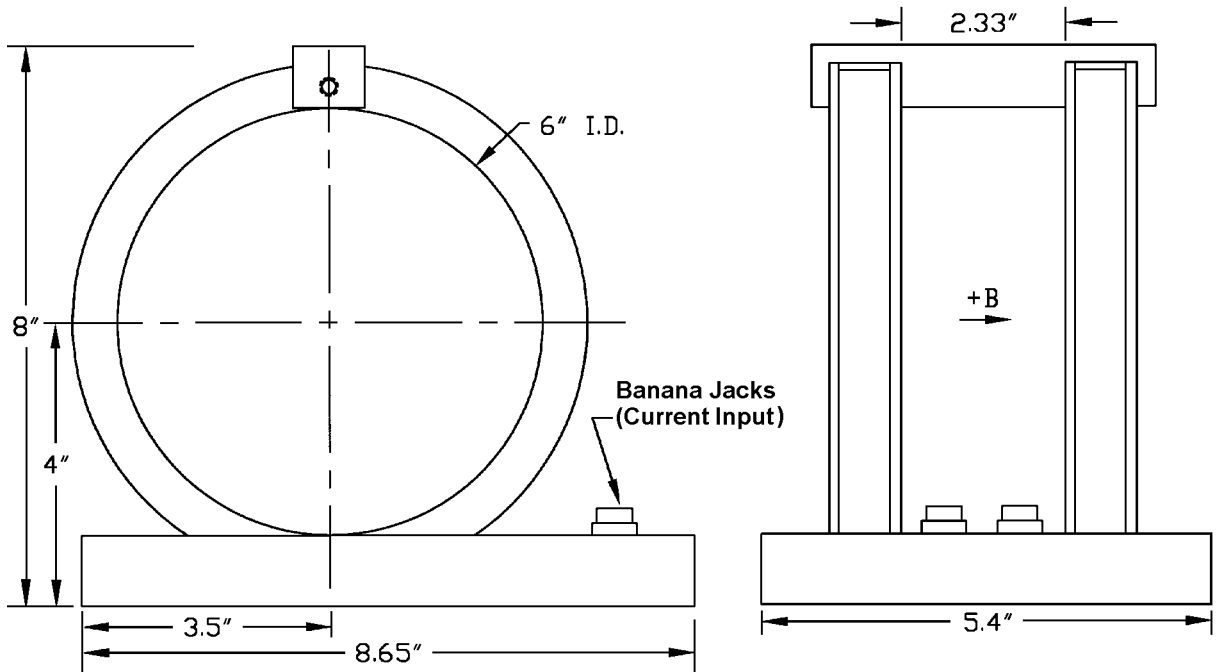
Figure 5-9. Model MH-6 Helmholtz Coil
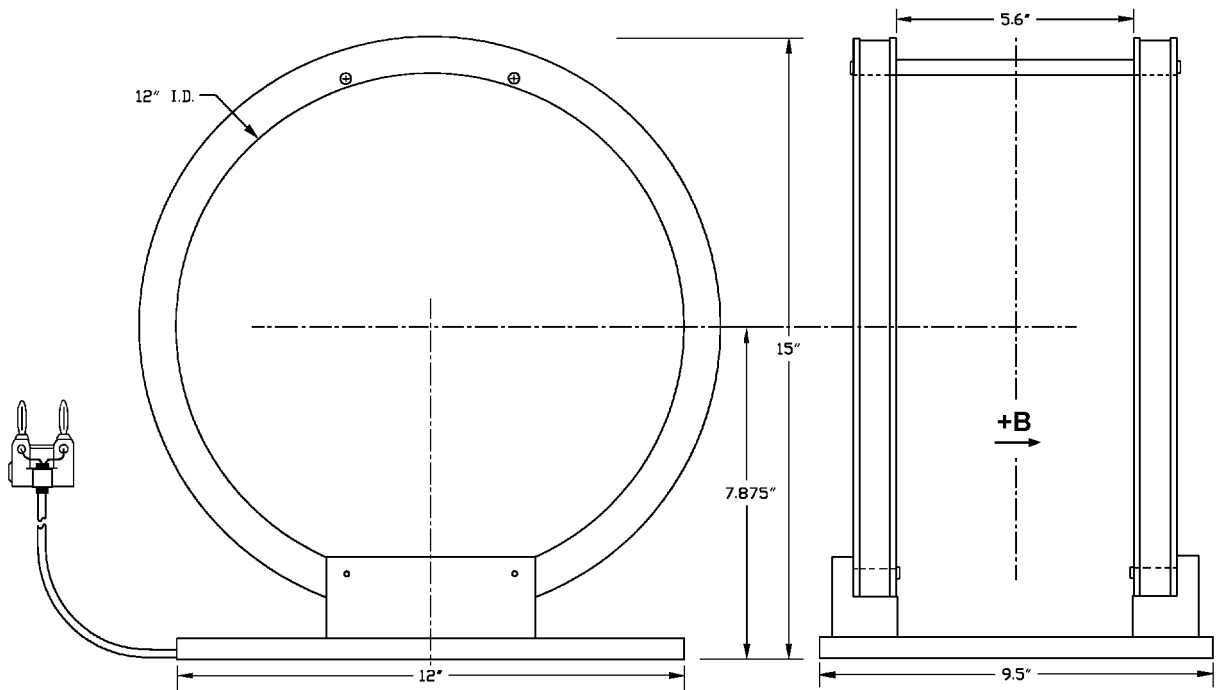
Figure 5-10. Model MH-12 Helmholtz Coil

5.4 REFERENCE MAGNETS

Magnetic reference standards containing highly stable permanent magnets have been in use for many years. The highest quality units are usually shielded from external magnetic effects and use Alnico V or VI magnets for long-term stability. They are supplied in both transverse (flat) and axial configurations.

Typical flat reference magnets are usually stabilized for use at ambient temperatures between 0 – 50 °C and have nominal temperature coefficients of about –0.02%/°C. Because the temperature coefficient is negative, the field strength will be reduced as the temperature rises. Since these references are temperature cycled during manufacture, their change with temperature is predictable and retraceable; they will always return to a known value at any specific ambient temperature.

The high-permeability shell which surrounds the reference magnet serves two function: (1) it shields the magnet from external field, and (2) serves as the flux return path. Physical damage to the outer shell can cause a permanent change in the gap flux density. Reference magnets should not be dropped or physically abused. Magnets of this type can have magnetic reference values ranging from 100 G to 20 kG, but the most widely-used value is 1 kG. Reference magnets accuracy is typically ±0.5%, except for magnets of 200 G or less; for these magnets, the limit of error is generally ±1%. The reference magnet gap is nominally 0.060 inch but may range from 0.040 to 0.250 inch for special units. The usable "plateau" in the reference gap generally encompasses an area of about 0.5 square inches.

In reference magnets used for axial field probes, Alnico V or VI is the usual magnet material, charged to saturation and stabilized down to a particular value. The same temperature coefficients hold true as in the transverse probe and the same care in handling must be observed. This assembly uses concentric mu-metal shield cans to protect the magnet from the effects of external magnetic field. Axial reference magnets are available in values up to 1 kG, with 500 G being the most widely-used value.

When a probe is inserted completely through the access guide, three distinct magnetic peaks will be observed on the gaussmeter. One peak occurs as the probe enters the magnet, a second (and greater) peak is observed as the midpoint is reached, and a third (smaller) peak is read as the probe leaves the magnet. The calibration point is the largest reading in the midpoint area. Its amplitude will be approximately twice that of the readings that occur where the probe enters or leaves the magnet.
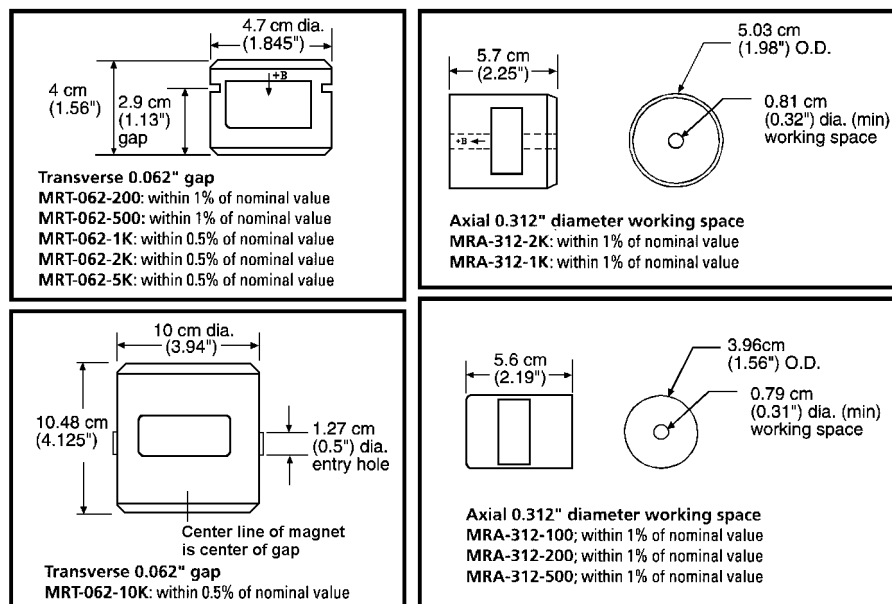
P-421-5-11.bmp

Figure 5-11. Lake Shore Reference Magnets

NOTE: Use care to ensure the Zero Gauss Chamber does not become magnetized. Using a magnetized chamber to zero a probe can lead to erroneous field readings. It is a good practice to periodically degauss the chamber. If no professional degausser is available, a bulk tape degausser (Verity VS250, Data Devices PF211, or equivalent) may be used.
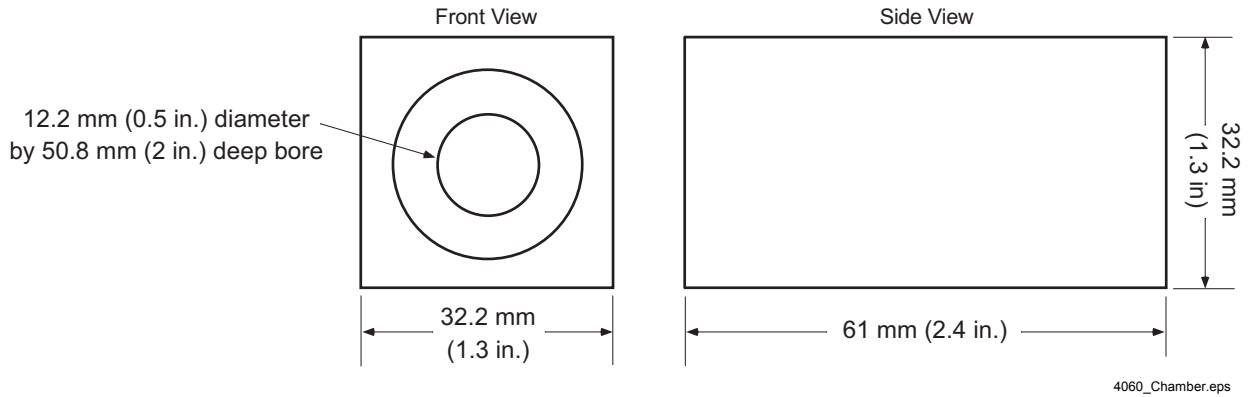
Figure 5-12. Model 4060 Zero Gauss Chamber
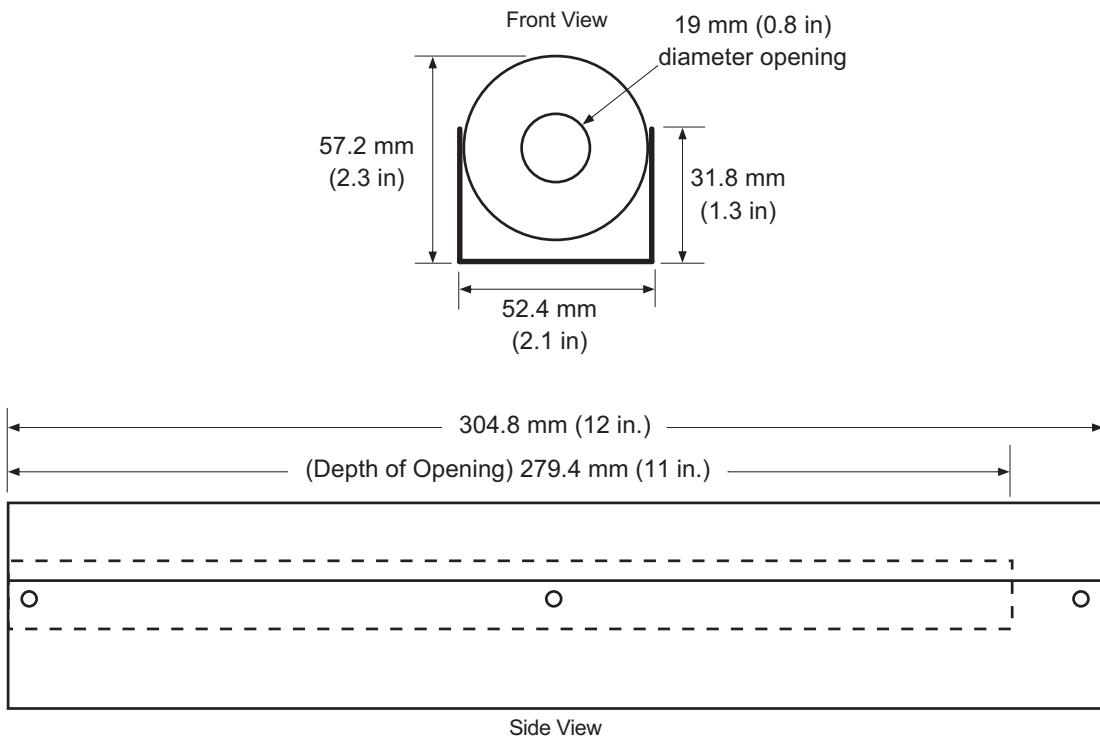
Figure 5-13. Model 4065 Large Zero Gauss Chamber

NOTE

Customer must use 5/64" (2 mm) hex key to remove four existing screws from sides of instrument.

Unit on right side mounting shown. Unit on left side also possible.

Item	Description	P/N	Qty
1	Rack Mount Ear	107-440	1
2	Rack Mount Support	107-442	1
3	Rack Mount Panel	107-432	1
4	Rack Mount Handle	107-051-01	2
5	Screw, 6-32 × 1/2 Inch FHMS Phillips	0-035	4
6	Screw, 8-32 × 3/8 Inch FHMS Phillips	0-081	6
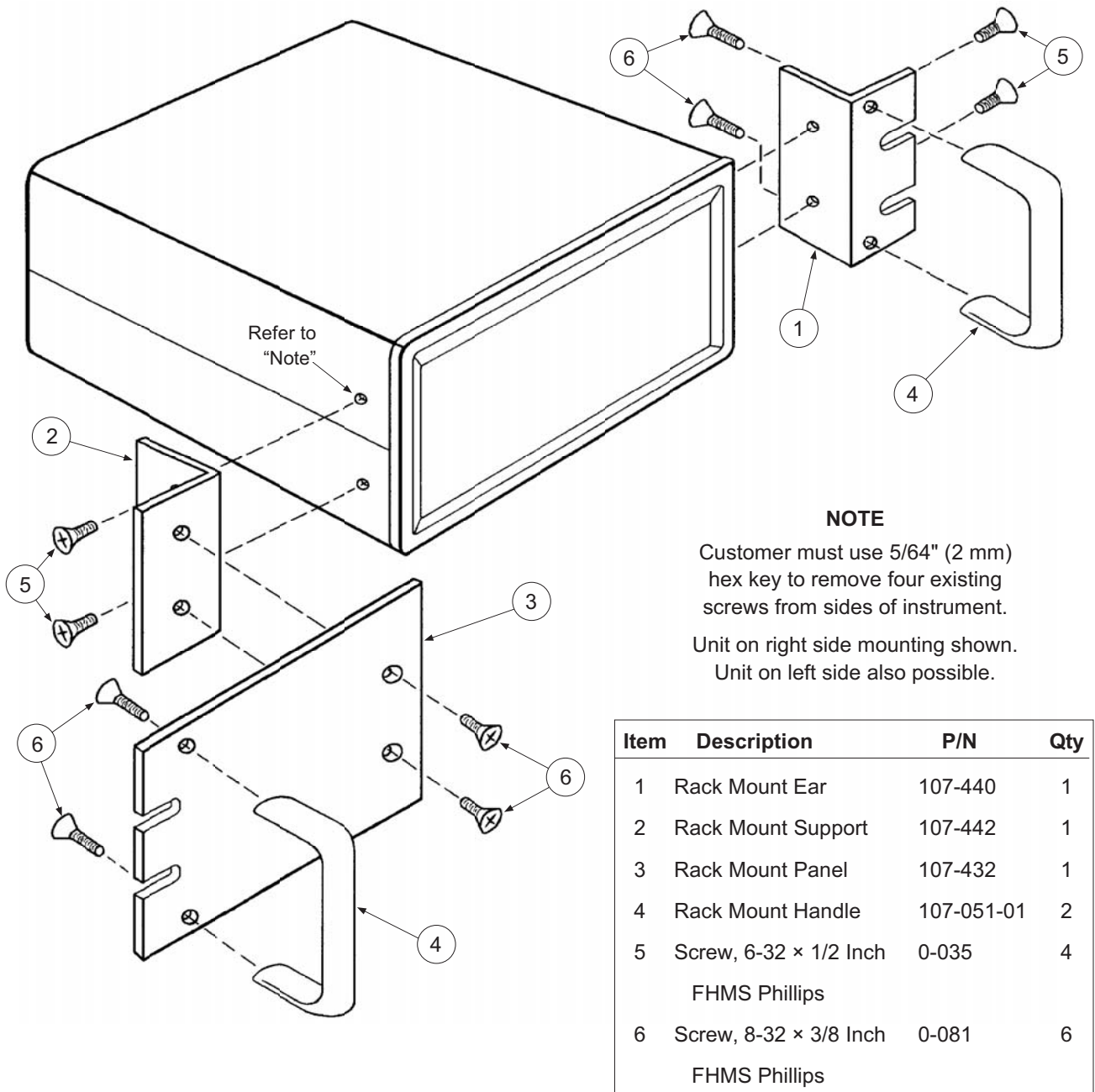
RM12_Rack.eps

Figure 5-14. Model RM-1/2 Rack-Mount Kit

Refer to "Installation Procedure"
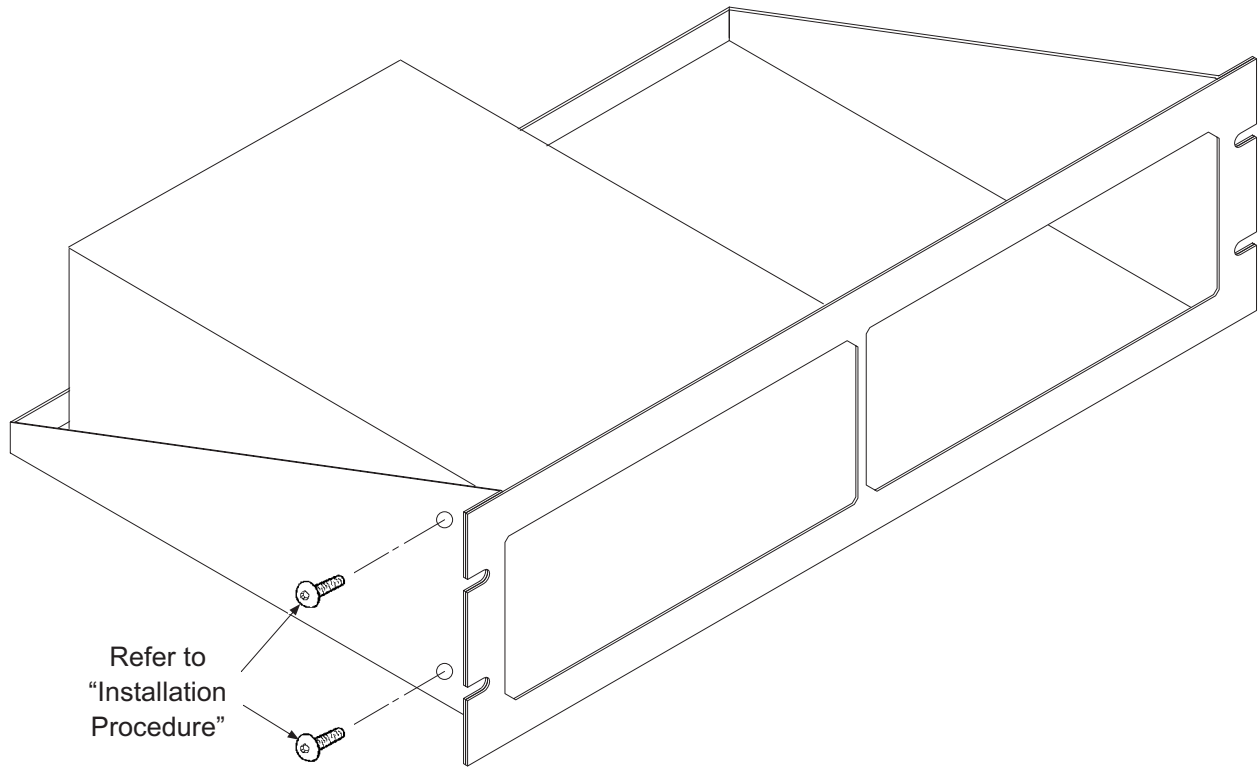
Installation Procedure

1. Use 5/64 inch (2 mm) hex key to remove two 6-32 x 1/4 black button head screws from side of Gaussmeter.

2. Place Gaussmeter on shelf.

3. Use 5/64 inch (2 mm) hex key to reinstall two 6-32 x 1/4 black button head screws through side of rack into corresponding holes in the side of the Gaussmeter.

RM2_Dual_Rack.eps

Figure 5-15. Model RM-2 Dual Rack-Mount Shelf

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CHAPTER 6

SERVICE

6.0   GENERAL

This chapter provides general service and calibration information for the Lake Shore Model 421 Gaussmeter. General maintenance precautions are described in Paragraph 6.1, electrostatic discharge in Paragraph 6.2, line voltage selection in Paragraph 6.3, fuse replacement in Paragraph 6.4, rear panel connector definitions in Paragraph 6.5, top of enclosure remove and replace procedure in Paragraph 6.6, EPROM replacement in Paragraph 6.7, and error messages in Paragraph 6.8.

There are no field serviceable parts inside the Model 421. Contact Lake Shore about specific problems with the Model 421.

6.1   GENERAL MAINTENANCE PRECAUTIONS

Below are general safety precautions unrelated to any other procedure in this publication. These are recommended precautions that personnel should understand and apply during the maintenance phase.

Keep away from live circuits. Installation personnel shall observe all safety regulations at all times. Turn off system power before making or breaking electrical connections. Regard any exposed connector, terminal board, or circuit board as a possible shock hazard. Discharge charged components only when such grounding results in no equipment damage. If a test connection to energized equipment is required, make the test equipment ground connection before probing the voltage or signal to be tested.

Do not install or service equipment alone. Do not reach into or adjust the equipment without having another person nearby capable of rendering aid.

If there is no power, verify the power cord is plugged into a live outlet and that both ends are securely plugged in. Next, check the fuse.

Use this procedure to periodically clean the Model 421 to remove dust, grease, and other contaminants:

1.   Clean front and back panels and case with soft cloth dampened with a mild detergent and water solution.

NOTE: Do *not* use aromatic hydrocarbons or chlorinated solvents to clean the Model 421. They may react with the plastic materials used in the controller or the silk screen printing on the back panel.

2.   Clean the surface of printed circuit boards (PCBs) with clean, dry air at low pressure.

6.2   ELECTROSTATIC DISCHARGE

Electrostatic Discharge (ESD) may damage electronic parts, assemblies, and equipment. ESD is a transfer of electrostatic charge between bodies at different electrostatic potentials caused by direct contact or induced by an electrostatic field. The low-energy source that most commonly destroys Electrostatic Discharge Sensitive (ESDS) devices is the human body, which generates and retains static electricity. Simply walking across a carpet in low humidity may generate up to 35,000 volts of static electricity.

Current technology trends toward greater complexity, increased packaging density, and thinner dielectrics between active elements, which results in electronic devices with even more ESD sensitivity. Some electronic parts are more ESDS than others. ESD levels of only a few hundred volts may damage electronic components such as semiconductors, thick and thin film resistors, and piezoelectric crystals during testing, handling, repair, or assembly. Discharge voltages below 4000 volts cannot be seen, felt, or heard.

6.2.1 Identification of Electrostatic Discharge Sensitive Components

Below are various industry symbols used to label components as ESDS:
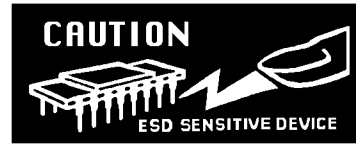
6.2.2 Handling Electrostatic Discharge Sensitive Components

Observe all precautions necessary to prevent damage to ESDS components before attempting installation. Bring the device and everything that contacts it to ground potential by providing a conductive surface and discharge paths. As a minimum, observe these precautions:

1. De-energize or disconnect all power and signal sources and loads used with unit.
2. Place unit on a grounded conductive work surface.
3. Ground technician through a conductive wrist strap (or other device) using 1 MΩ series resistor to protect operator.
4. Ground any tools, such as soldering equipment, that will contact unit. Contact with operator's hands provides a sufficient ground for tools that are otherwise electrically isolated.
5. Place ESDS devices and assemblies removed from a unit on a conductive work surface or in a conductive container. An operator inserting or removing a device or assembly from a container must maintain contact with a conductive portion of the container. Use only plastic bags approved for storage of ESD material.
6. Do not handle ESDS devices unnecessarily or remove from the packages until actually used or tested.

6.3 LINE VOLTAGE SELECTION

Use the following procedure to change the instrument line voltage selector. Verify the fuse value whenever line voltage is changed.

WARNING: To avoid potentially lethal shocks, turn off controller and disconnect it from AC power before performing these procedures.

1. Identify the line input assembly on the instrument rear panel. See Figure 6-1.
2. Turn the line power switch OFF (**O**).
3. Remove the instrument power cord.
4. With a small screwdriver, release the drawer holding the line voltage selector and fuse.
5. Slide out the removable plastic fuse holder from the drawer.
6. Rotate the fuse holder until the proper voltage indicator shows through the window.
7. Verify the proper fuse value.
8. Re-assemble the line input assembly in the reverse order.
9. Verify the voltage indicator in the window of the line input assembly.
10. Connect the instrument power cord.
11. Turn the line power switch On (**I**).
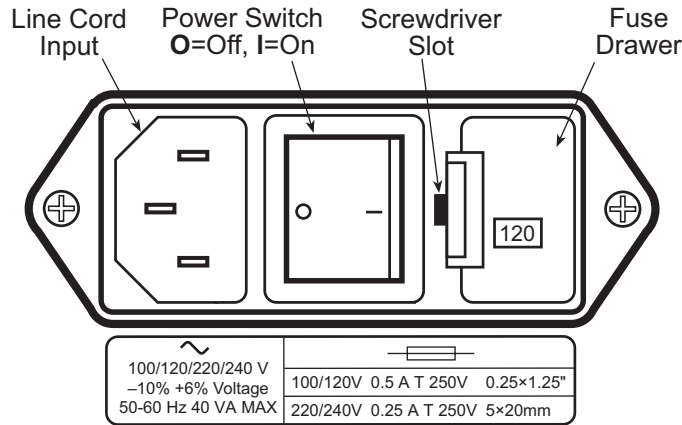
Figure 6-1. Power Fuse Access

6.4 FUSE REPLACEMENT

Below is the procedure to remove and replace a line fuse. There are two basic power configurations: U.S. and International. Units produced for use in the U.S. have a single fuse on the hot. Units produced for International use have a double fuse for the hot and neutral. To change line input from the factory setting, use the appropriate fuse in the connector kit shipped with the instrument. Test fuse with ohmmeter. Do not rely on visual inspection of fuse.

WARNING: To avoid potentially lethal shocks, turn off controller and disconnect it from AC power before performing these procedures.

CAUTION: For continued protection against fire hazard, replace only with the same fuse type and rating specified for the line for the line voltage selected.

1. Locate line input assembly on the instrument rear panel. See Figure 6-1.
2. Turn power switch Off (**O**).
3. Remove instrument power cord.
4. With a small screwdriver, release the drawer holding the line voltage selector and fuse.
5. Remove existing fuse(s). Replace with proper Slow-Blow fuse ratings as follows:

100/120 V	0.5 A T 250 V	0.25 × 1.25 inches
220/240 V	0.25 A T 250 V	5 × 20 mm

6. Re-assemble line input assembly in reverse order.
7. Verify voltage indicator in the line input assembly window.
8. Connect instrument power cord.
9. Turn power switch On (**I**).

6.5 REAR PANEL CONNECTOR DEFINITIONS

The connectors on the rear panel of the Model 421 Gaussmeter are detailed in Figures 6-2 thru 6-5. Additional details for various external serial cables are provided in Paragraphs 6.5 1.

PROBE INPUT

CAUTION: POWER OFF TO MATE PROBE

*View Looking At Rear
Of Model 421*
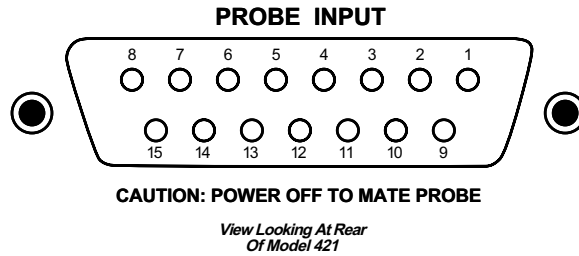
C-480-6-2.eps

PIN	DESCRIPTION
1	Input + (Analog Signal)
2	No Connection
3	No Connection
4	No Connection
5	No Connection
6	No Connection
7	No Connection
8	I_C +
9	Input - (Analog Signal Ground)
10	No Connection
11	Digital Ground
12	+5 Volts (Power Output To Probe EEPROM)
13	EE-CLK (Output To Probe EEPROM)
14	EE-DATA (Serial Input From Probe EEPROM)
15	I_C -

Figure 6-2. PROBE INPUT Connector Details

ANALOG OUTPUTS
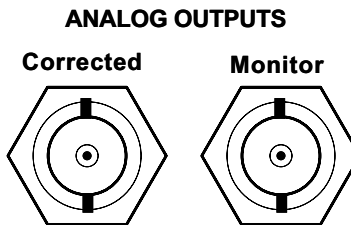
Corrected   **Monitor**

C-421-6-3.eps

PIN	DESCRIPTION
1	Analog Output – Center Conductor
2	Ground – Connector Shell

Figure 6-3. Corrected and Monitor ANALOG OUTPUTS Connector Details

Slides into RELAY slot
at rear of Model 421

Use screwdriver to
lock or unlock wires

Terminal Block Connector
Lake Shore P/N 106-741

Insert wire
into slot

NC C NO
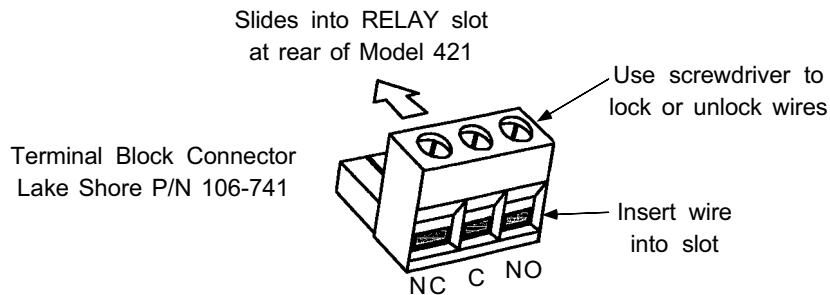
C-421-6-4.eps

PIN	DESCRIPTION
1	Normally Closed (NC)
2	Common (C)
3	Normally Open (NO)

Figure 6-4. RELAY Terminal Block Details

SERIAL I/O (DTE)

5 4 3 2 1

9 8 7 6

*View Looking At Rear
Of Model 421*
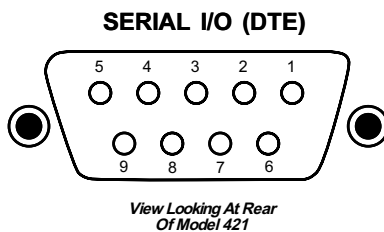
C-421-6-5.eps

Model 421 Gaussmeter (DTE)		Computers and Printers (DTE)			
DE-9P		DB-25P		DE-9P	
Pin	Description	Pin	Description	Pin	Description
1	No Connection	2	TD (out)	1	DCD (in)
2	Receive Data (RD in)	3	RD (in)	2	RD (in)
3	Transmit Data (TD out)	4	RTS (out)	3	TD (out)
4	Data Terminal Ready (DTR out)	5	CTS (in)	4	DTR (out)
5	Ground (GND)	6	DSR (in)	5	GND
6	Data Set Ready (DSR in)	7	GND	6	DSR (in)
7	Data Terminal Ready (DTR out) (tied to 4)	8	DCD (in)	7	RTS (out)
8	No Connection	20	DTR (out)	8	CTS (in)
9	No Connection	22	Ring in (in)	9	Ring in (in)

Figure 6-5. SERIAL I/O (DTE) Connector Details

6.5.1 Serial Interface Cable Wiring

The following are suggested cable wiring diagrams for connecting the Model 421 Serial Interface to various Customer Personal Computers (PCs).

Model 421 to PC Serial Interface – PC with DE-9P

Model 421 DE-9P	Standard **Null-Modem** Cable (DE-9S to DE-9S)	PC DE-9P
5 - GND		5 - GND
2 - RD (in)		3 - TD (out)
3 - TD (out)		2 - RD (in)
4 - DTR (out)		6 - DSR (in)
6 - DSR (in)		4 - DTR (out)
1 - NC		7 - RTS (out)
7 - DTR (tied to 4)		8 - CTS (in)
8 - NC		1 - DCD (in)

Model 421 to PC Serial Interface – PC with DE-25P

Model 421 DE-9P	Standard **Null-Modem** Cable (DE-9S to DB-25S)	PC DB-25P
5 - GND		7 - GND
2 - RD (in)		2 - TD (out)
3 - TD (out)		3 - RD (in)
1 - NC		4 - RTS (out)
7 - DTR (tied to 4)		5 - CTS (in)
8 - NC		8 - DCD (in)
6 - DSR (in)		20 - DTR (out)
4 - DTR (out)		6 - DSR (in)

Model 421 to PC Interface using Null Modem Adapter

Model 421 DE-9P	**Null Modem** Adapter	PC DE-9P
5 - GND		5 - GND
2 - RD (in)		3 - TD (out)
3 - TD (out)		2 - RD (in)
1 - NC		4 - DTR (out)
6 - DSR (in)		1 - DCD (in)
4 - DTR (out)		6 - DSR (in)
7 - DTR (tied to 4)		8 - CTS (in)
8 - NC		7 - RTS (out)
9 - NC		9 - NC

NOTE: Same as null modem cable design except PC CTS is provided from the Model 421 on DTR.

6.6   TOP OF ENCLOSURE REMOVAL AND REPLACEMENT

WARNING: To avoid potentially lethal shocks, turn off gaussmeter and disconnect it from AC power line before performing this procedure. Only qualified personnel should perform this procedure.

6.6.1   Removal Procedure

1.   Turn power switch Off (**O**).
2.   Remove instrument power cord.
3.   If attached, remove rack mounting brackets.
4.   Use 5/64 hex key to remove four screws attaching top panel to unit.
5.   Use 5/64 hex key to loosen two rear screws attaching bottom panel to unit.
6.   Carefully remove the back bezel by sliding it straight back away from the unit.
7.   Slide the top panel back and remove it from the unit.

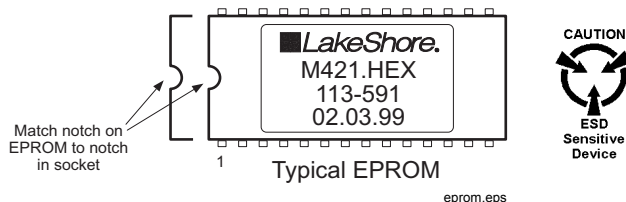**6.6.2   Installation Procedure**

1.   Slide the top panel forward in the track provided on each side of the unit.
2.   Carefully replace the back bezel by sliding it straight into the unit.
3.   Use 5/64 hex key to install four screws attaching top panel to unit.
4.   Use 5/64 hex key to tighten two rear screws attaching bottom panel to unit.
5.   If required, reattach rack mounting brackets.
6.   Attach instrument power cord.
7.   Turn power switch On (**I**).

6.7   EPROM REPLACEMENT

The operating software for the Model 421 is contained on one Erasable Programmable Read Only Memory (EPROM) Integrated Circuit (IC). The reference designator for the EPROM is U36, Lake Shore Part Number 113-591. The EPROM has a sticker on top labeled with "M421.HEX" and the date. Use the following procedure to replace the EPROM.

CAUTION: The EPROM is an Electrostatic Discharge Sensitive (ESDS) device. Wear shock-proof wrist straps (with a resistor that limits current to <5 mA) to prevent injury to service personnel and to avoid inducing an Electrostatic Discharge (ESD) into the device. Refer to Paragraph 6.2.

1.   Follow the top of enclosure REMOVAL procedure in Paragraph 6.6.1.
2.   Remove four phillips-head screws attaching transformer bracket to the Model 421 chassis. Carefully pull transformer bracket up and sufficiently out of the way to gain access to the Operating Software EPROM. See Figure 6-6.
3.   Locate EPROM U36 (M421.HEX) on the main circuit board. Note orientation of existing IC.

Match notch on EPROM to notch in socket

■*LakeShore.*
M421.HEX
113-591
02.03.99

1   Typical EPROM

CAUTION

ESD
Sensitive
Device

eprom.eps

4.   Use IC puller to remove existing EPROM from socket.
5.   Noting orientation of new EPROM, use an IC insertion tool to place new device into socket.
6.   Install four phillips-head screws attaching transformer bracket to the Model 421 chassis.
7.   Follow the top of enclosure INSTALLATION procedure in Paragraph 6.6.2.
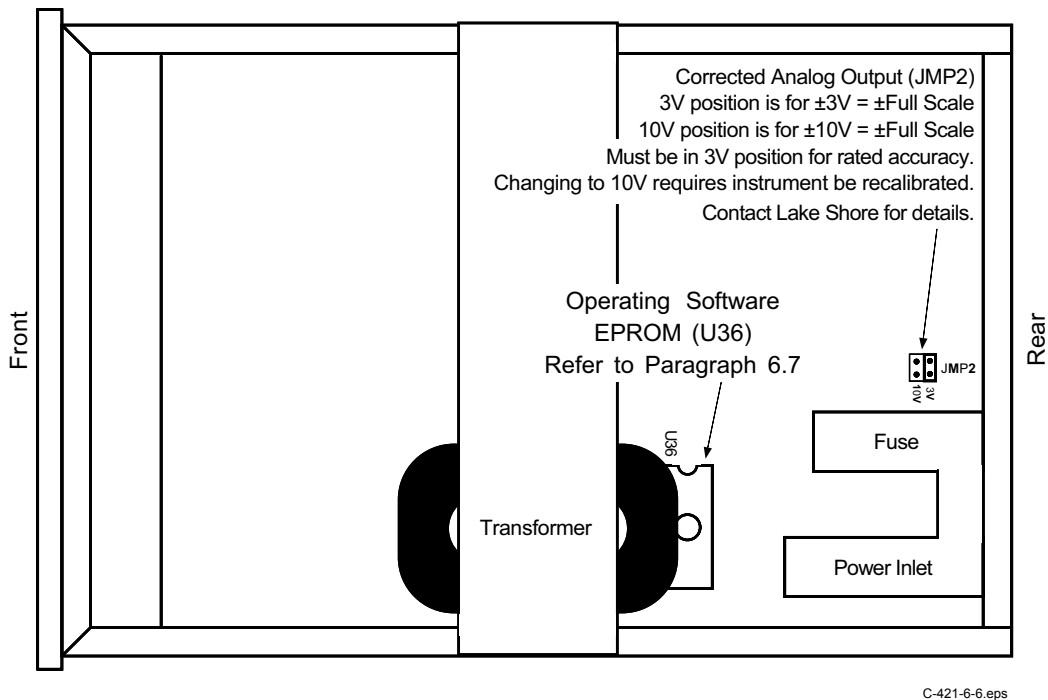
C-421-6-6.eps

Figure 6-6. Location of Operation Software EPROM and Analog Output Jumper

6.8   ERROR MESSAGES

The following is a list of Model 421 error messages that may be seen during normal operation.

OL   Field range has been exceeded. Refer to Paragraph 3.5 to change Range.

** No Probe **   No probe attached to the instrument at power up. Power the instrument off, attach a probe, and power it on again.

Locked   Keypad is locked to prevent accidental parameter changes. To unlock keypad refer to Paragraph 3.13.

Error 1   NOVRAM memory is physically malfunctioning. Contact Lake Shore service for repair.

Error2   NOVRAM memory is not initialized properly. Memory can be reinitialized as described in Paragraph 3.15. This operation will **not** restore calibration data that may have been corrupted. Instrument calibration should be checked after any Error 2 condition. Contact Lake Shore service for repair or calibration.

APPENDIX A

GLOSSARY OF TERMINOLOGY

accuracy. The degree of correctness with which a measured value agrees with the true value.[2]

    electronic accuracy. The accuracy of an instrument independent of the sensor.

    sensor accuracy. The accuracy of a Hall generator and its associated calibration.

American Standard Code for Information Exchange (ASCII). A standard code used in data transmission, in which 128 numerals, letters, symbols, and special control codes are represented by a 7-bit binary number as follows:

b_4 b_3 b_2 b_1	Row	Col. 0	1	2	3	4	5	6	7
0 0 0 0	0	NUL	DLE	SP	0	@	P	`	p
0 0 0 1	1	SOH	DC1	!	1	A	Q	a	q
0 0 1 0	2	STX	DC2	"	2	B	R	b	r
0 0 1 1	3	ETX	DC3	#	3	C	S	c	s
0 1 0 0	4	EOT	DC4	$	4	D	T	d	t
0 1 0 1	5	ENG	NAK	%	5	E	U	e	u
0 1 1 0	6	ACK	SYN	&	6	F	V	f	v
0 1 1 1	7	BEL	ETB	'	7	G	W	g	w
1 0 0 0	8	BS	CAN	(	8	H	X	h	x
1 0 0 1	9	HT	EM	)	9	I	Y	i	y
1 0 1 0	10	LF	SS	*	:	J	Z	j	z
1 0 1 1	11	VT	ESC	+	;	K	[	k	{
1 1 0 0	12	FF	FS	,	<	L	~	l	|
1 1 0 1	13	CR	GS	−	=	M	]	m	}
1 1 1 0	14	SO	RS	.	>	N	^	n	l
1 1 1 1	15	SI	US	/	?	O	_	o	DEL

American Wire Gage (AWG). Wiring sizes are defined as diameters in inches and millimeters as follows:

AWG	Dia. In.	Dia. mm	AWG	Dia. In.	Dia. mm	AWG	Dia. In.	Dia. mm	AWG	Dia. In.	Dia. mm
1	0.2893	7.348	11	0.0907	2.304	21	0.0285	0.7230	31	0.0089	0.2268
2	0.2576	6.544	12	0.0808	2.053	22	0.0253	0.6438	32	0.0080	0.2019
3	0.2294	5.827	13	0.0720	1.829	23	0.0226	0.5733	33	0.00708	0.178
4	0.2043	5.189	14	0.0641	1.628	24	0.0207	0.5106	34	0.00630	0.152
5	0.1819	4.621	15	0.0571	1.450	25	0.0179	0.4547	35	0.00561	0.138
6	0.1620	4.115	16	0.0508	1.291	26	0.0159	0.4049	36	0.00500	0.127
7	0.1443	3.665	17	0.0453	1.150	27	0.0142	0.3606	37	0.00445	0.1131
8	0.1285	3.264	18	0.0403	1.024	28	0.0126	0.3211	38	0.00397	0.1007
9	0.1144	2.906	19	0.0359	0.9116	29	0.0113	0.2859	39	0.00353	0.08969
10	0.1019	2.588	20	0.0338	0.8118	30	0.0100	0.2546	40	0.00314	0.07987

ampere. The constant current that, if maintained in two straight parallel conductors of infinite length, of negligible circular cross section, and placed one meter apart in a vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per meter of length.[2] This is one of the base units of the SI.

ampere-turn. A MKS unit of magnetomotive force equal to the magnetomotive force around a path linking one turn of a conducting loop carrying a current of one ampere; or 1.26 gilberts.

ampere/meter (A/m). The SI unit for magnetic field strength (H). 1 ampere/meter = $4\pi/1000$ oersted ≈ 0.01257 oersted.

analog data. Data represented in a continuous form, as contrasted with digital data having discrete values.[1]

analog output. A voltage output from an instrument that is proportional to its input. From an instrument such as a digital voltmeter, the output voltage is generated by a digital-to-analog converter with a discrete number of voltage levels.

anode. The terminal that is positive with respect to the other terminal when the diode is biased in the forward direction.[2]

+ Anode ━▶┤├━ Cathode −

area. A measure of the size of a two-dimensional surface, or of a region on such a surface.[1]

area·turns. A coil parameter produced by the multiplication of a magnet's area and number of turns. Gives an indication of the sensitivity of a coil.

B. Symbol for magnetic flux density. *See* Magnetic Flux Density.

baud. A unit of signaling speed equal to the number of discrete conditions or signal events per second, or the reciprocal of the time of the shortest signal element in a character.[2]

bit. A contraction of the term "binary digit"; a unit of information represented by either a zero or a one.[2]

calibration. To determine, by measurement or comparison with a standard, the correct (accurate) value of each scale reading on a meter or other device, or the correct value for each setting of a control knob.[1]

cathode. The terminal from which forward current flows to the external circuit.[2]

$$+ \quad \text{Anode} \longrightarrow\!\!\mid\!\longleftarrow \text{Cathode} \quad -$$

Celsius (°C) Scale. A temperature scale that registers the freezing point of water as 0 °C and the boiling point as 100 °C under normal atmospheric pressure. Celsius degrees are purely derived units, calculated from the Kelvin Thermodynamic Scale. Formerly known as "centigrade." *See* Temperature for conversions.

cgs system of units. A system in which the basic units are the centimeter, gram, and second.[2]

coercive force (coercive field). The magnetic field strength (H) required to reduce the magnetic induction (B) in a magnetic material to zero.

coercivity. generally used to designate the magnetic field strength (H) required to reduce the magnetic induction (B) in a magnetic material to zero from saturation. The coercivity would be the upper limit to the coercive force.

compliance voltage. *See* current source.

Curie temperature (Tc). Temperature at which a magnetized sample is completely demagnetized due to thermal agitation. Named for Pierre Curie (1859 – 1906), a French chemist.

current source. A type of power supply that supplies a constant current through a variable load resistance by automatically varying its compliance voltage. A single specification given as "compliance voltage" means the output current is within specification when the compliance voltage is between zero and the specified voltage.

demagnetization. when a sample is exposed to an applied field (H_a), poles are induced on the surface of the sample. Some of the returned flux from these poles is inside of the sample. This returned flux tends to decrease the net magnetic field strength internal to the sample yielding a true internal field (H_{int}) given by: $H_{int} = H_a - DM$,where M is the volume magnetization and D is the demagnetization factor. D is dependent on the sample geometry and orientation with respect to the field.

deviation. The difference between the actual value of a controlled variable and the desired value corresponding to the setpoint.[1]

differential permeability. The slope of a B versus H curve: $\mu_d = dB/dH$.

differential susceptibility. The slope of a M versus H curve: $\chi_d = dM/dH$.

digital controller. A feedback control system where the feedback device (sensor) and control actuator (heater) are joined by a digital processor. In Lake Shore controllers the heater output is maintained as a variable DC current source.

digital data. Pertaining to data in the form of digits or interval quantities. Contrast with analog data.[2]

dimensionless sensitivity. Sensitivity of a physical quantity to a stimulus, expressed in dimensionless terms. The dimensionless temperature sensitivity of a resistance temperature sensor is expressed as $S_d = (T/R)(dR/dT)$ which is also equal to the slope of R versus T on a log-log plot, that is $S_d = d \ln R / d \ln T$. Note that the absolute temperature (in kelvin) must be used in these expressions.

drift, instrument. An undesired but relatively slow change in output over a period of time, with a fixed reference input. *Note:* Drift is usually expressed in percent of the maximum rated value of the variable being measured.[2]

electromagnet. A device in which a magnetic field is generated as the result of electrical current passing through a helical conducting coil. It can be configured as an iron-free solenoid in which the field is produced along the axis of the coil, or an iron-cored structure in which the field is produced in an air gap between pole faces. The coil can be water cooled copper or aluminum, or superconductive.

electron. An elementary particle containing the smallest negative electric charge. *Note:* The mass of the electron is approximately equal to 1/1837 of the mass of the hydrogen atom.[2]

electrostatic discharge (ESD). A transfer of electrostatic charge between bodies at different electrostatic potentials caused by direct contact or induced by an electrostatic field.

error. Any discrepancy between a computed, observed, or measured quantity and the true, specified, or theoretically correct value or condition.[2]

Fahrenheit (°F) Scale. A temperature scale that registers the freezing point of water as 32 °F and the boiling point as 212 °F under normal atmospheric pressure. *See* Temperature for conversions.

flux (φ). The electric or magnetic lines of force in a region.[1]

flux density (B). Any vector field whose flux is a significant physical quantity; examples are magnetic flux density, electric displacement, and gravitational field.[1]

gamma. A cgs unit of low-level flux density, where 100,000 gamma equals one oersted, or 1 gamma equals 10^{-5} oersted.

gauss (G). The cgs unit for magnetic flux density (B). 1 gauss = 10^{-4} tesla = 1 Mx/cm^2 = line/cm^2. Named for Karl Fredrich Gauss (1777 – 1855) a German mathematician, astronomer, and physicist.

gaussian system (units). A system in which centimeter-gram-second units are used for electric and magnetic qualities.

general purpose interface bus (GPIB). Another term for the IEEE-488 bus.

gilbert (Gb). A cgs electromagnetic unit of the magnetomotive force required to produce one maxwell of magnetic flux in a magnetic circuit of unit reluctance. One gilbert is equal to $10/4\pi$ ampere-turn. Named for William Gilbert (1540 – 1603), an English physicist; hypothesized that the earth is a magnet.

gilbert per centimeter. Practical cgs unit of magnet intensity. Gilberts per cm are the same as oersteds.

Greek alphabet. The Greek alphabet is defined as follows:

Alpha	α	A	Iota	ι	I	Rho	ρ	P
Beta	β	B	Kappa	κ	K	Sigma	σ	Σ
Gamma	γ	Γ	Lambda	λ	Λ	Tau	τ	T
Delta	δ	Δ	Mu	μ	M	Upsilon	υ	Y
Epsilon	ε	E	Nu	ν	N	Phi	φ	Φ
Zeta	ζ	Z	Xi	ξ	Ξ	Chi	χ	X
Eta	η	H	Omicron	o	O	Psi	ψ	Ψ
Theta	θ	Θ	Pi	π	Π	Omega	ω	Ω

ground. A conducting connection, whether intentional or accidental, by which an electric circuit or equipment is connected to the earth, or to some conducting body of large extent that serves in place of the earth. *Note:* It is used for establishing and maintaining the potential of the earth (or of the conducting body) or approximately that potential, on conductors connected to it, and for conducting ground current to and from the earth (or of the conducting body).[2]

H. Symbol for magnetic field strength. *See* Magnetic Field Strength.

Hall effect. The generation of an electric potential perpendicular to both an electric current flowing along a thin conducting material and an external magnetic field applied at right angles to the current. Named for Edwin H. Hall (1855 – 1938), an American physicist.

Hall mobility. The quantity μH in the relation $\mu H = R\sigma$, where R = Hall coefficient and σ = conductivity.[2]

Helmholtz coils. A pair of flat, circular coils having equal numbers of turns and equal diameters, arranged with a common axis, and connected in series; used to obtain a magnetic field more nearly uniform than that of a single coil.[1]

hertz (Hz). A unit of frequency equal to one cycle per second.

hole. A mobile vacancy in the electronic valence structure of a semiconductor that acts like a positive electron charge with a positive mass.[2]

hysteresis. The dependence of the state of a system on its previous history, generally in the form of a lagging of a physical effect behind its cause.[1] Also *see* magnetic hysteresis.

IEEE. Institute of Electrical and Electronics Engineers.

IEEE-488. An instrumentation bus with hardware and programming standards designed to simplify instrument interfacing. The addressable, parallel bus specification is defined by the IEEE.

initial permeability. The permeability determined at H = 0 and B = 0.

initial susceptibility. The susceptibility determined at H = 0 and M = 0.

integrator. A circuit or network whose output waveform is the time integral of its input waveform.[1]

international system of units (SI). A universal coherent system of units in which the following seven units are considered basic: meter, kilogram, second, ampere, kelvin, mole, and candela. The International System of Units, or Système International d'Unités (SI), was promulgated in 1960 by the Eleventh General Conference on Weights and Measures. For definition, spelling, and protocols, *see* Reference 3 for a short, convenient guide.

interpolation table. A table listing the output and sensitivity of a sensor at regular or defined points which may be different from the points at which calibration data was taken.

intrinsic coercivity. The magnetic field strength (H) required to reduce the magnetization (M) or intrinsic induction in a magnetic material to zero.

intrinsic induction. The contribution of the magnetic material (B_i) to the total magnetic induction (B).

$$B_i = B - \mu_o H \quad \text{(SI)} \qquad\qquad B_i = B - H \quad \text{(cgs)}$$

isolated (neutral system). A system that has no intentional connection to ground except through indicating, measuring, or protective devices of very-high impedance.[2]

Kelvin (K). The unit of temperature on the Kelvin Scale. It is one of the base units of SI. The word "degree" and its symbol (°) are omitted from this unit. *See* Temperature Scale for conversions.

Kelvin Scale. The Kelvin Thermodynamic Temperature Scale is the basis for all international scales, including the ITS-90. It is fixed at two points: the absolute zero of temperature (0 K), and the triple point of water (273.16 K), the equilibrium temperature that pure water reaches in the presence of ice and its own vapor.

line regulation. The maximum steady-state amount that the output voltage or current will change as the result of a specified change in input line voltage (usually for a step change between 105 – 125 or 210 – 250 volts, unless otherwise specified).

line of flux. An imaginary line in a magnetic field of force whose tangent at any point gives the direction of the field at that point; the lines are spaced so that the number through a unit area perpendicular to the field represents the intensity of the field. Also know as a Maxwell in the cgs system of units.

line voltage. The RMS voltage of the primary power source to an instrument.

load regulation. A steady-state decrease of the value of the specified variable resulting from a specified increase in load, generally from no-load to full-load unless otherwise specified.

M. Symbol for magnetization. *See* magnetization.

magnetic air gap. The air space, or non-magnetic portion, of a magnetic circuit.

magnetic field strength (H). The magnetizing force generated by currents and magnetic poles. For most applications, the magnetic field strength can be thought of as the applied field generated, for example, by a superconducting magnet. The magnetic field strength is not a property of materials. Measure in SI units of A/m or cgs units of oersted.

magnetic flux density (B). Also referred to as magnetic induction. This is the net magnetic response of a medium to an applied field, H. The relationship is given by the following equation: $B = \mu_o(H + M)$ for SI, and $B = H + 4\pi M$ for cgs, where H = magnetic field strength, M = magnetization, and μ_o = permeability of free space = $4\pi \times 10^{-7}$ H/m.

magnetic hysteresis. The property of a magnetic material where the magnetic induction (B) for a given magnetic field strength (H) depends upon the past history of the samples magnetization.

magnetic induction (B). *See* magnetic flux density.

magnetic moment (m). This is the fundamental magnetic property measured with dc magnetic measurements systems such as a vibrating sample magnetometer, extraction magnetometer, SQUID magnetometer, etc. The exact technical definition relates to the torque exerted on a magnetized sample when placed in a magnetic field. Note that the moment is a total attribute of a sample and alone does not necessarily supply sufficient information in understanding material properties. A small highly magnetic sample can have exactly the same moment as a larger weakly magnetic sample (*see* Magnetization). Measured in SI units as $A \cdot m^2$ and in cgs units as emu. 1 emu = 10^{-3} $A \cdot m^2$.

magnetic scalar potential. The work which must be done against a magnetic field to bring a magnetic pole of unit strength from a reference point (usually at infinity) to the point in question. Also know as magnetic potential.[1]

magnetic units. Units used in measuring magnetic quantities. Includes ampere-turn, gauss, gilbert, line of force, maxwell, oersted, and unit magnetic pole.

magnetization (M). This is a material specific property defined as the magnetic moment (m) per unit volume (V). M = m/V. Measured in SI units as A/m and in cgs units as emu/cm^3. 1 emu/cm^3 = 10^3 A/m. Since the mass of a sample is generally much easier to determine than the volume, magnetization is often alternately expressed as a mass magnetization defined as the moment per unit mass.

magnetostatic. Pertaining to magnetic properties that do not depend upon the motion of magnetic fields.[1]

mains. *See* line voltage.

Maxwell (Mx). A cgs electromagnetic unit of magnetic flux, equal to the magnetic flux which produces an electromotive force of 1 abvolt in a circuit of one turn link the flux, as the flux is reduced to zero in 1 second at a uniform rate.[1]

MKSA System of Units. A system in which the basic units are the meter, kilogram, and second, and the ampere is a derived unit defined by assigning the magnitude $4\pi \times 10^{-7}$ to the rationalized magnetic constant (sometimes called the permeability of space).

NBS. National Bureau of Standards. Now referred to as NIST.

National Institute of Standards and Technology (NIST). Government agency located in Gaithersburg, Maryland and Boulder, Colorado, that defines measurement standards in the United States. *See* Standards Laboratories for an international listing.

noise (electrical). Unwanted electrical signals that produce undesirable effects in circuits of control systems in which they occur.[2]

normalized sensitivity. For resistors, signal sensitivity (dR/dT) is geometry dependent; i.e., dR/dT scales directly with R; consequently, very often this sensitivity is normalized by dividing by the measured resistance to give a sensitivity, s_T, in percent change per kelvin. s_T = (100/R) (dR/dT) %K, where T is the temperature in kelvin and R is the resistance in ohms.

normally closed (N.C.). A term used for switches and relay contacts. Provides a closed circuit when actuator is in the free (unenergized) position.

normally open (N.O.). A term used for switches and relay contacts. Provides an open circuit when actuator is in the free (unenergized) position.

oersted (Oe). The cgs unit for the magnetic field strength (H). 1 oersted = $10^3/4\pi$ ampere/meter $\approx$ 79.58 ampere/meter.

ohm (Ω). The SI unit of resistance (and of impedance). The ohm is the resistance of a conductor such that a constant current of one ampere in it produces a voltage of one volt between its ends.[2]

pascal (Pa). The SI unit of pressure equal to 1 N/m^2. Equal to 1.45×10^{-4} psi, 1.0197×10^{-5} kg_f /cm^2, 7.5×10^{-3} torr, 4.191×10^{-3} inches of water, or 1×10^{-5} bar.

permeability. Material parameter which is the ratio of the magnetic induction (B) to the magnetic field strength (H): μ = B/H. Also *see* Initial Permeability and Differential Permeability.

polynomial fit. A mathematical equation used to fit calibration data. Polynomials are constructed of finite sums of terms of the form $a_i x_i$, where a_i is the ith fit coefficient and x_i is some function of the dependent variable.

pounds per square inch (psi). A unit of pressure. 1 psi = 6.89473 kPa. Variations include psi absolute (psia) measured relative to vacuum (zero pressure) where one atmosphere pressure equals 14.696 psia and psi gauge (psig) where gauge measured relative to atmospheric or some other reference pressure.

ppm. Parts per million, e.g., 4×10^{-6} is four parts per million.

precision. Careful measurement under controlled conditions which can be repeated with similar results. *See* repeatability. Also means that small differences can be detected and measured with confidence. *See* resolution.

prefixes. SI prefixes used throughout this manual are as follows:

Factor	Prefix	Symbol	Factor	Prefix	Symbol
10^{24}	yotta	Y	10^{-1}	deci	d
10^{21}	zetta	Z	10^{-2}	centi	c
10^{18}	exa	E	10^{-3}	milli	m
10^{15}	peta	P	10^{-6}	micro	μ
10^{12}	tera	T	10^{-9}	nano	n
10^{9}	giga	G	10^{-12}	pico	p
10^{6}	mega	M	10^{-15}	femto	f
10^{3}	kilo	k	10^{-18}	atto	a
10^{2}	hecto	h	10^{-21}	zepto	z
10^{1}	deka	da	10^{-24}	yocto	y

probe. A long, thin body containing a sensing element which can be inserted into a system in order to make measurements. Typically, the measurement is localized to the region near the tip of the probe.

remanence. The remaining magnetic induction in a magnetic material when the material is first saturated and then the applied field is reduced to zero. The remanence would be the upper limit to values for the remanent induction. Note that no strict convention exists for the use of remanent induction and remanence and in some contexts the two terms may be used interchangeably.

remanent induction. The remaining magnetic induction in a magnetic material after an applied field is reduced to zero. Also *see* remanence.

repeatability. The closeness of agreement among repeated measurements of the same variable under the same conditions.[2]

resolution. The degree to which nearly equal values of a quantity can be discriminated.[2]

 display resolution. The resolution of an instrument's physical display. This is not always the same as the measurement resolution of the instrument. Decimal display resolution specified as "n digits" has 10^n possible display values. A resolution of n and one-half digits has 2×10^n possible values.

 measurement resolution. The ability of an instrument to resolve a measured quantity. For digital instrumentation this is often defined by the analog to digital converter being used. A n-bit converter can resolve one part in 2^n. The smallest signal change that can be measured is the full scale input divided by 2^n for any given range. Resolution should not be confused with accuracy.

root mean square (RMS). The square root of the time average of the square of a quantity; for a periodic quantity the average is taken over one complete cycle. Also known as effective value.[1]

RS-232C. Bi-directional computer serial interface standard defined by the Electronic Industries Association (EIA). The interface is single-ended and non-addressable.

scalar. A quantity which has magnitude only and no direction, in contrast to a vector.[1]

semiconducting material. A conducting medium in which the conduction is by electrons, and holes, and whose temperature coefficient of resistivity is negative over some temperature range below the melting point.[2]

semiconductor. An electronic conductor, with resistivity in the range between metals and insulators, in which the electric charge carrier concentration increases with increasing temperature over some temperature range. Note: Certain semiconductors possess two types of carriers, namely, negative electrons and positive holes.[2]

sensitivity. The ratio of the response or change induced in the output to a stimulus or change in the input. Temperature sensitivity of a resistance temperature detector is expressed as S = dR/dT.

setpoint. The value selected to be maintained by an automatic controller.[1]

serial interface. A computer interface where information is transferred one bit at a time rather than one byte (character) at a time as in a parallel interface. RS-232C is a common serial interface.
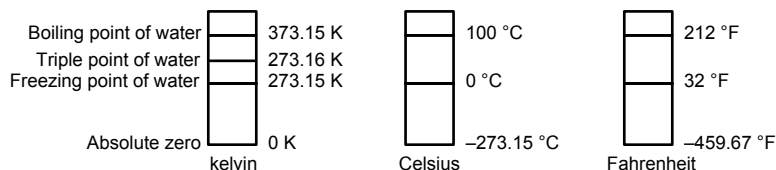
SI. Système International d'Unités. *See* International System of Units.

stability. The ability of an instrument or sensor to maintain a constant output given a constant input.

susceptance. In electrical terms, susceptance is defined as the reciprocal of reactance and the imaginary part of the complex representation of admittance: [suscept(ibility) + (conduct)ance].

susceptibility (χ). Parameter giving an indication of the response of a material to an applied magnetic field. The susceptibility is the ratio of the magnetization (M) to the applied field (H). χ = M/H. In both SI units and cgs units the volume susceptibility is a dimensionless parameter. Multiply the cgs susceptibility by 4π to yield the SI susceptibility. *See* also Initial Susceptibility and Differential Susceptibility. As in the case of magnetization, the susceptibility is often seen expressed as a mass susceptibility or a molar susceptibility depending upon how M is expressed.

temperature scales. *See* Kelvin Scale, Celsius Scale, and ITS-90. Proper metric usage requires that only kelvin and degrees Celsius be used. However, since degrees Fahrenheit is in such common use, all three scales are delineated as follows:

	kelvin	Celsius	Fahrenheit
Boiling point of water	373.15 K	100 °C	212 °F
Triple point of water	273.16 K		
Freezing point of water	273.15 K	0 °C	32 °F
Absolute zero	0 K	−273.15 °C	−459.67 °F

To convert kelvin to Celsius, subtract 273.15.
To convert Celsius to Fahrenheit: multiply °C by 1.8 then add 32, or: °F = (1.8 × °C) + 32.
To convert Fahrenheit to Celsius: subtract 32 from °F then divide by 1.8, or: °C = (°F − 32) / 1.8.

temperature coefficient, measurement. The measurement accuracy of an instrument is affected by changes in ambient temperature. The error is specified as an amount of change (usually in percent) for every one degree change in ambient temperature.

tesla (T). The SI unit for magnetic flux density (B). 1 tesla = 10^4 gauss

thermal emf. An electromotive force arising from a difference in temperature at two points along a circuit, as in the Seebeck effect.[1]

tolerance. The range between allowable maximum and minimum values.

turns (N). One complete loop of wire.

Underwriters Laboratories (UL). An independent laboratory that establishes standards for commercial and industrial products.

unit magnetic pole. A pole with a strength such that when it is placed 1 cm away from a like pole, the force between the two is 1 dyne.

vector. A quantity that has both magnitude and direction, and whose components transform from one coordinate system to another in the same manner as the components of a displacement. Also known as a polar vector.[1]

volt (V). The difference of electric potential between two points of a conductor carrying a constant current of one ampere, when the power dissipated between these points is equal to one watt.[2]

volt-ampere (VA). The SI unit of apparent power. The volt-ampere is the apparent power at the points of entry of a single-phase, two-wire system when the product of the RMS value in amperes of the current by the RMS value in volts of the voltage is equal to one.[2]

watt (W). The SI unit of power. The watt is the power required to do work at the rate of 1 joule per second.[2]

weber (Wb). The unit of magnetic flux in the mks system, equal to the magnetic flux which, linking a circuit of one turn, produces in it an electromotive force of 1 volt as it is reduced to zero at a uniform rate in 1 second.[1]

References:

1   Sybil P. Parker, Editor. *Dictionary of Scientific and Technical Terms: Third Edition*. New York: McGraw Hill, 1969 (IBSN 0-395-20360-0)

2   Christopher J. Booth, Editor. *The New IEEE Standard Dictionary of Electrical and Electronic Terms: IEEE Std 100-1992, Fifth Edition.* New York: Institute of Electrical and Electronics Engineers, 1993 (IBSN 1-55937-240-0). Definitions printed with permission of the IEEE.

3   Nelson, Robert A. *Guide For Metric Practice,* Page BG7 - 8, Physics Today, Eleventh Annual Buyer's Guide, August 1994 (ISSN 0031-9228 coden PHTOAD)

APPENDIX B

UNITS FOR MAGNETIC PROPERTIES

Table B-1. Conversion from CGS to SI Units

Quantity	Symbol	Gaussian and CGS emu[a]	Conversion Factor, C[b]	SI and Rationalized mks[c]
Magnetic flux density, Magnetic induction	B	gauss (G)[d]	10^{-4}	tesla (T), Wb/m^2
Magnetic Flux	ϕ	maxwell (Mx), $G{\cdot}cm^2$	10^{-8}	weber (Wb), volt second (V•s)
Magnetic potential difference, magnetomotive force	U, F	gilbert (Gb)	$10/4\pi$	ampere (A)
Magnetic field strength, magnetizing force	H	oersted (Oe),[e] Gb/cm	$10^3/4\pi$	A/m[f]
(Volume) magnetization[g]	M	emu/cm^3[h]	10^3	A/m
(Volume) magnetization	$4\pi M$	G	$10^3/4\pi$	A/m
Magnetic polarization, intensity of magnetization	J, I	emu/cm^3	$4\pi \times 10^{-4}$	T, Wb/m^2[i]
(Mass) magnetization	σ, M	emu/g	1 $4\pi \times 10^{-7}$	$A{\cdot}m^2/kg$ Wb•m/kg
Magnetic moment	m	emu, erg/G	10^{-3}	$A{\cdot}m^2$, joule per tesla (J/T)
Magnetic dipole moment	j	emu, erg/G	$4\pi \times 10^{-10}$	Wb•m[i]
(Volume) susceptibility	χ, κ	dimensionless emu/cm^3	— $(4\pi)^2 \times 10^{-7}$	Henry per meter (H/m), Wb/(A•m)
(Mass) susceptibility	χ_ρ, κ_ρ	cm^3/g, emu/g	$4\pi \times 10^{-3}$ $(4\pi)2 \times 10^{-10}$	m^3/kg $H{\cdot}m^2/kg$
(Molar) susceptibility	χ_{mol}, κ_{mol}	cm^3/mol, emu/mol	$4\pi \times 10^{-6}$ $(4\pi)^2 \times 10^{-13}$	m^3/mol $H{\cdot}m^2/mol$
Permeability	μ	dimensionless	$4\pi \times 10^{-7}$	H/m, Wb/(A•m)
Relative permeability[j]	μ_r	not defined	—	dimensionless
(Volume) energy density, energy product[k]	W	erg/cm^3	10^{-1}	J/m^3
Demagnetization factor	D, N	dimensionless	$1/4\pi$	dimensionless

NOTES:

a. Gaussian units and cgs emu are the same for magnetic properties. The defining relation is B = H + 4πM.

b. Multiply a number in Gaussian units by C to convert it to SI (e.g. 1 G × 10^{-4}T/G = 10^{-4}T).

c. SI (Système International d'Unités) has been adopted by the National Bureau of Standards. Where two conversion factors are given, the upper one is recognized under, or consistent with, SI and is based on the definition B = μ_0(H + M), where to μ_0 = $4\pi \times 10^{-7}$H/m. The lower one is not recognized under SI and is based on the definition B = μ_0H + J, where the symbol I is often used in place of J.

d. 1 gauss = 10^5 gamma (γ).

e. Both oersted and gauss are expressed as $cm^{-\frac{1}{2}} {\cdot}g^{\frac{1}{2}}{\cdot}s^{-1}$ in terms of base units.

f. A/m was often expressed as "ampere-turn per meter" when used for magnetic field strength.

g. Magnetic moment per unit volume.

h. The designation "emu" is not a unit.

i. Recognized under SI, even though based on the definition B = μ_0H + J. See footnote c.

j. μ_r = μ/μ_0 = 1 + χ, all in SI. μ_r is equal to Gaussian μ.

k. B • H and μ_0M • H have SI units J/m^3, M • H and B • H/4π have Gaussian units erg/cm^3.

Table B-2. Recommended SI Values for Physical Constants

Quantity	Symbol	Value (SI units)
Permeability of Vacuum	μ_0	$4\pi \times 10^{-7}$ H m^{-1}
Speed of Light in Vacuum	c	2.9979×10^{8} m s^{-1}
Permitivity of Vacuum	$\varepsilon_0 = (\mu_0 c^2)^{-1}$	8.8542×10^{-12} F m^{-1}
Fine Structure Constant, $\mu_0 c e^2/2h$	α α^{-1}	0.0073 137.0360
Elementary Charge	e	1.6022×10^{-19} C
Plank's Constant	h $h = h/2\pi$	6.6262×10^{-34} J Hz^{-1} 1.0546×10^{-34} J s
Avogadro's Constant	N_A	6.0220×10^{23} mol^{-1}
Atomic Mass Unit	1 u = 10^{-3} kg mol^{-1}/N_A	1.6605×10^{-27} kg
Electron Rest Mass	m_e	0.9109×10^{-30} kg 5.4858×10^{-4} u
Proton Rest Mass	m_p	1.6726×10^{-27} kg 1.0073 u
Neutron Rest Mass	m_n	1.6749×10^{-27} kg 1.0087 u
Magnetic Flux Quantum	$\phi = h/2e$ h/e	2.0679×10^{-15} Wb 4.1357×10^{-15} J Hz^{-1} C^{-1}
Josephson Frequency-Voltage Ratio	2e/h	483.5939 THz V^{-1}
Quantum of Circulation	$h/2m_e$ h/m_e	3.6369×10^{-4} J Hz^{-1} kg^{-1} 7.2739×10^{-4} J Hz^{-1} C^{-1}
Rydberg Constant	R_∞	1.0974×10^{7} m^{-1}
Proton Moment in Nuclear Magnetons	μ_p/μ_N	2.7928
Bohr Magneton	$\mu_B = eh/2m_e$	9.2741×10^{-24} J T^{-1}
Proton Gyromagnetic Ratio	γ_p	2.6752×10^{8} s^{-1} T^{-1}
Diamagnetic Shielding Factor, Spherical H_2O Sample	$1 + \sigma(H_2O)$	1.0000
Molar Mass Constant	R	8.3144 J mol^{-1} K^{-1}
Molar Volume, Ideal Gas (T_0 = 273.15K, p_0 = 1 atm)	$V_m = RT_0/p_0$	0,0224 m^3 mol^{-1}
Boltzman Constant	$k = R/N_A$	1.3807×10^{-23} J K^{-1}
Stefan-Boltzman Constant	$\sigma = (\pi^2/60) k^4/h^3 c^2$	5.6703×10^{-8} W m^{-2} K^{-4}
First Radiation Constant	$c_1 = 2\pi hc^2$	3.7418×10^{-16} W m^{-2}
Second Radiation Constant	$c_2 = hc/k$	0.0144 mK
Gravitation Constant	G	6.6720×10^{-11} N m^2 kg^{-2}

Data (abbreviated to 4 decimal places) from CODATA Bulletin No. 11, ICSU CODATA Central Office, 19 Westendstrasse, 6 Frankfurt/Main, Germany. Copies of this bulletin are available from this office.

APPENDIX C

HALL GENERATORS

C1.0   GENERAL

This chapter provides theory of operation, specifications, mechanical drawings, and definition of terminology. Hall Generator theory of operation is detailed in Paragraph C2.0. Generic Hall generator hookup is detailed in Paragraph C3.0. Hookup to a Model 421 Gaussmeter is discussed in Paragraph C4.0. Specifications of the various available Hall generators are detailed in Paragraph C5.0. Finally, the HALLCAL.EXE program is detailed in Paragraph C6.0. Additional installation and calibration information is available in Lake Shore Document Number F075-00-00 – Hall Generator Application Guide.

C2.0   THEORY OF OPERATION

The Hall effect was discovered by E. H. Hall in 1879. For nearly 70 years it remained a laboratory curiosity. Finally, development of semiconductors brought Hall generators into the realm of the practical.

A Hall generator is a solid state sensor which provides an output voltage proportional to magnetic flux density. As implied by its name, this device relies on the Hall effect. The Hall effect is the development of a voltage across a sheet of conductor when current is flowing and the conductor is placed in a magnetic field. See Figure C-1.

Electrons (the majority carrier most often used in practice) "drift" in the conductor when under the influence of an external driving electric field. When exposed to a magnetic field, these moving charged particles experience a force perpendicular to both the velocity and magnetic field vectors. This force causes the charging of the edges of the conductor, one side positive with respect to the other. This edge charging sets up an electric field which exerts a force on the moving electrons equal and opposite to that caused by the magnetic-field-related Lorentz force. The voltage potential across the width of the conductor is called the Hall voltage. This Hall voltage can be utilized in practice by attaching two electrical contacts to the sides of the conductor.

The Hall voltage can be given by the expression:

$$V_H = \gamma_B \, B \sin \theta$$

where: V_H = Hall voltage (mV)

$\quad\quad\gamma_B$ = Magnetic sensitivity (mV/kG) (at a fixed current)
$\quad\quad B$ = Magnetic field flux density (kilogauss)
$\quad\quad \theta$ = Angle between magnetic flux vector and the plane of Hall generator.

As can be seen from the formula, above, the Hall voltage varies with the angle of the sensed magnetic field, reaching a maximum when the field is perpendicular to the plane of the Hall generator.

C2.1   ACTIVE AREA

The Hall generator assembly contains the sheet of semiconductor material to which the four contacts are made. This entity is normally called a "Hall plate." The Hall plate is, in its simplest form, a rectangular shape of fixed length, width and thickness. Due to the shorting effect of the current supply contacts, most of the sensitivity to magnetic fields is contained in an area approximated by a circle, centered in the Hall plate, whose diameter is equal to the plate width. Thus, when the active area is given, the circle as described above is the common estimation.
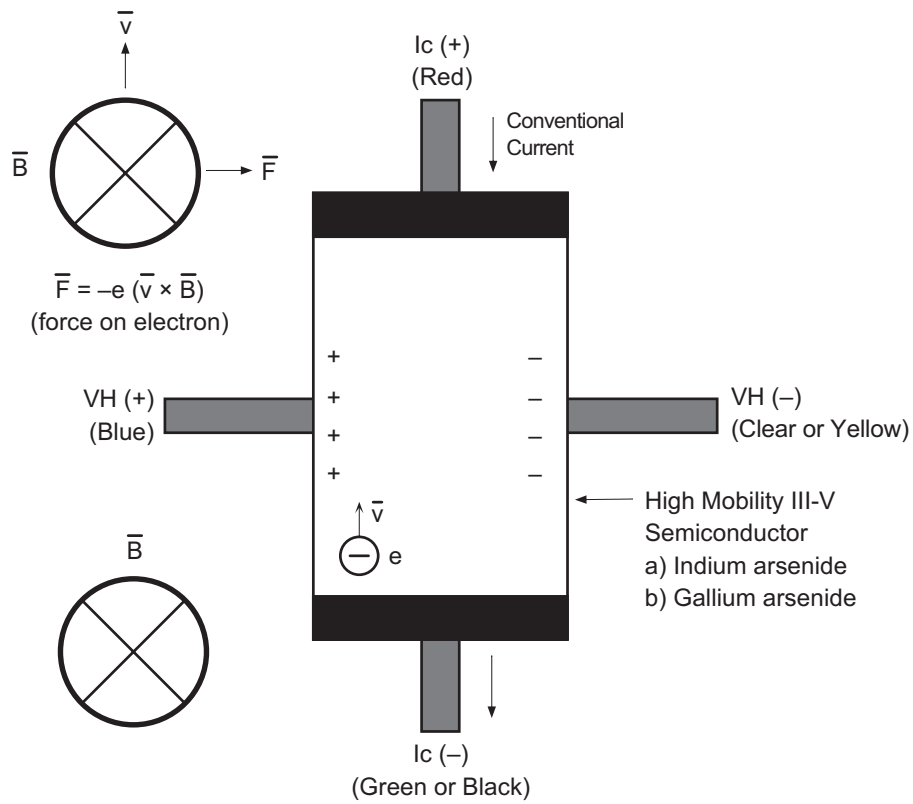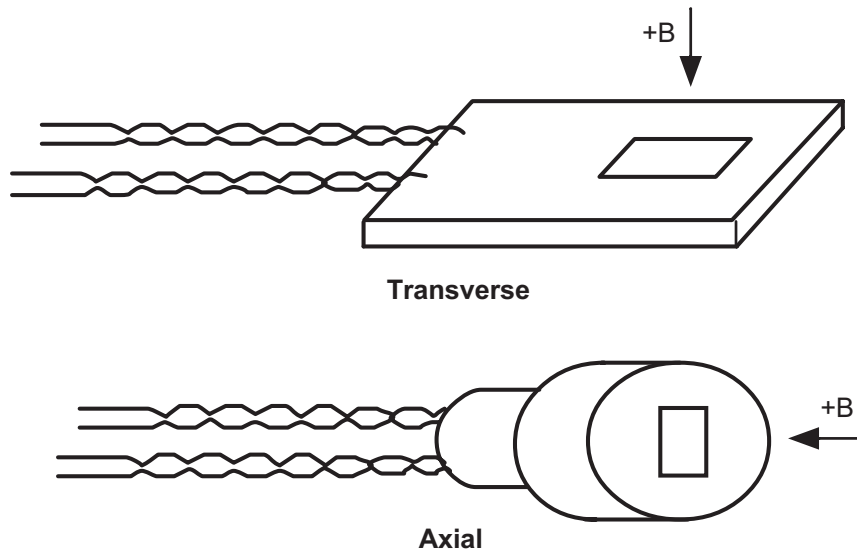
Figure C-1. Hall Generator Theory

C2.2   ORIENTATION

Hall generators come in two main configurations, axial and transverse. Transverse devices are generally thin and rectangular in shape. They are applied successfully in magnetic circuit gaps, surface measurements and general open field measurements. Axial sensors are mostly cylindrical in shape. Their applications include ring magnet center bore measurements, solenoids, surface field detection and general field sensing.

Figure C-2. Axial and Transverse Configurations

C2.3   HANDLING

CAUTION: Care must be exercised when handling the Hall generator. The Hall generator is very fragile. Stressing the Hall generator can alter its output. Any excess force can easily break the Hall generator. Broken Hall generators are not repairable.

Hall Generators are very fragile and require delicate handling. The ceramic substrate used to produce the Hall Generator is very brittle. Use the leads to move the Hall generator. Do not handle the substrate. The strength of the lead-to-substrate bond is about 7 ounces, so avoid tension on the leads and especially avoid bending them close to the substrate. The Hall Generator is also susceptible to bending and thermal stresses.

C2.4   POLARITY

If the control current enters the red lead (with $+I_C$ connected to the positive terminal of the current supply), and the magnetic field direction is as shown in Figure C-2, a positive Hall voltage will be generated at the blue lead ($+V_H$). Reversing either the current or the magnetic field will reverse the output voltage.

C2.5   LEAD CONFIGURATIONS

All Hall generators (except Models HGCA-3020 and HGCT-3020) have 34 AWG solid copper with poly-nylon insulation and have the same lead configuration as follows:

Red = $+I_C$
Green = $-I_C$ } Input (Control Current)

Blue = $+V_H$
Clear = $-V_H$ } Output (Hall Voltage)

The Model HGCA-3020 and HGCT-3020 Hall generators have 34 AWG stranded copper with Teflon® insulation and have the following lead configuration:

Red = $+I_C$
Black = $-I_C$ } Input (Control Current)

Blue = $+V_H$
Yellow = $-V_H$ } Output (Hall Voltage)

C3.0   HALL GENERATOR GENERIC HOOKUP

The Hall voltage leads may also be connected directly to a readout instrument, such as a high impedance voltmeter, or can be attached to electronic circuitry for amplification or conditioning. Device signal levels will be in the range of microvolts to hundreds of millivolts. In this case, a separate precision current source (Lake Shore Model 120CS or equivalent) is necessary. See Figure C-3.

CAUTION: The four Hall generator leads connect to four points on a sheet of semiconductor material having different potentials. No two leads can be connected together without adversely affecting operation. Therefore, the current source and the output indicator cannot have a common connection, but must be isolated from each other. One, the other, but not both, may be grounded.

CAUTION: Do not exceed the maximum continuous control current given in the specifications.

The Hall generator input is not isolated from its output. In fact, impedance levels on the order of the input resistance are all that generally exist between the two ports. To prevent erroneous current paths, which can cause large error voltages, the current supply must be isolated from the output display or the down stream electronics.
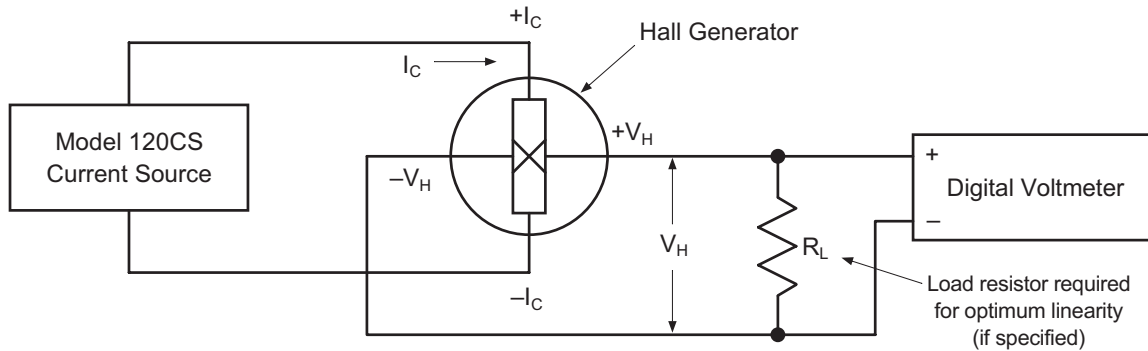
Figure C-3. Typical Hall Generator Hookup

## C4.0   USING A HALL GENERATOR WITH THE MODEL 421

To hookup a Hall generator you must use a Lake Shore Model MCBL-6 Cable Assembly. The cable is 200 cm (79 inches) long with a DA-15 connector on one end and four leads on the other. The Hall generator is a 4-lead device. The 4 leads are labeled +Ic (Red), –Ic (Black or Green), +VH (Blue), and –VH (Yellow), corresponding to the 4 leads on all the Hall generators.

The Model 421 has an input impedance of 420 Ω. Therefore, the actual sensitivity at the gaussmeter input will be less than the value given with the Hall generator due to drop in the leads and cable. This fact is important because a sensitivity value is supposed to be loaded into the cable PROM to set calibration. We recommend that the customer always check accuracy against a reference field rather than use the sensitivity value sent with the bare Hall generator. Because Lake Shore has no control of the conditions beyond the cable, the customer must accept responsibility for accuracy and compatibility.

Finally, Manganin wire is not usually acceptable for cryogenic installations. The resistance of Manganin wire is often too high. In cryogenic applications, Hall generators are normally connected using twisted pairs of copper wire such as 34 gauge, Teflon insulated. There are two reasons for this:

1. The gaussmeter current source is normally limited in compliance voltage. The Model 421 should not drive a load (Hall generator, Wires in cryostat, and probe cable) greater than 50 Ω. In fact, for best performance, the load should be less than 30 Ω.

2. Because the Model 421 input impedance is 420 Ω, there is a voltage drop due to lead resistance in series with the gaussmeter input. The Lake Shore Hall generator sensitivity given on the data sheet is basically with no lead resistance. See Figure C-4.
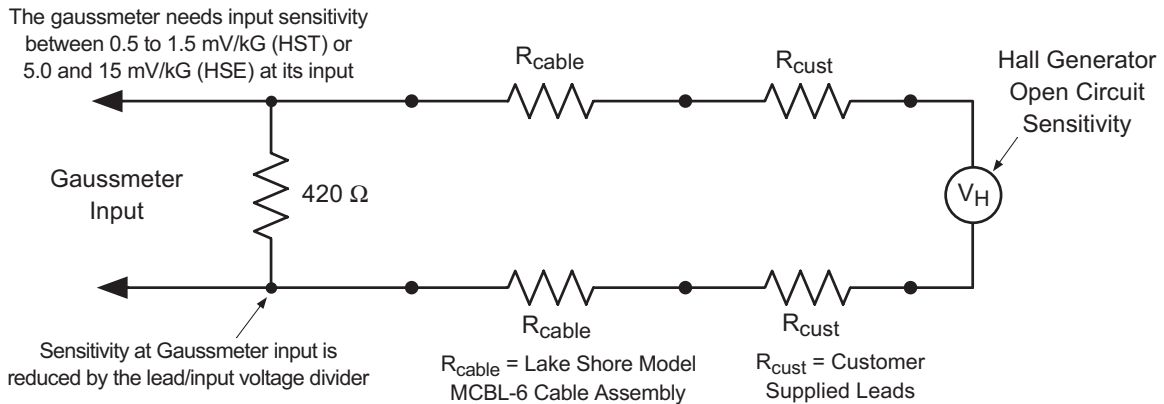

Figure C-4. Hall Generator Input Impedance

C5.0 SPECIFICATIONS

This section covers three types of Hall generators available from Lake Shore: HGCA & HGCT Series Cryogenic Hall generators (Figures C-5 and C-6) with specifications (Table C-1), HGA Series Axial Hall generators (Figures C-5 and C-7) with specifications (Table C-2), and HGT Series Transverse Hall generators (Figures C-8 thru C-10) with specifications (Table C-3).
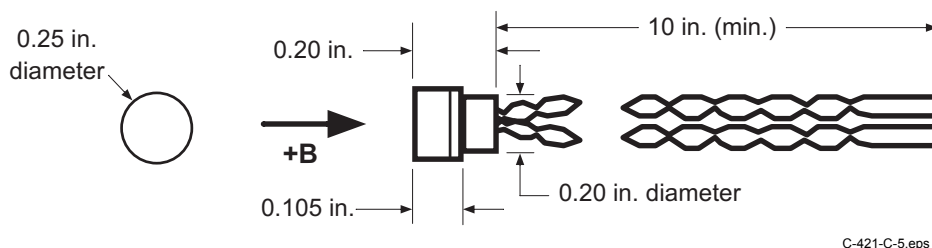
C-421-C-5.eps

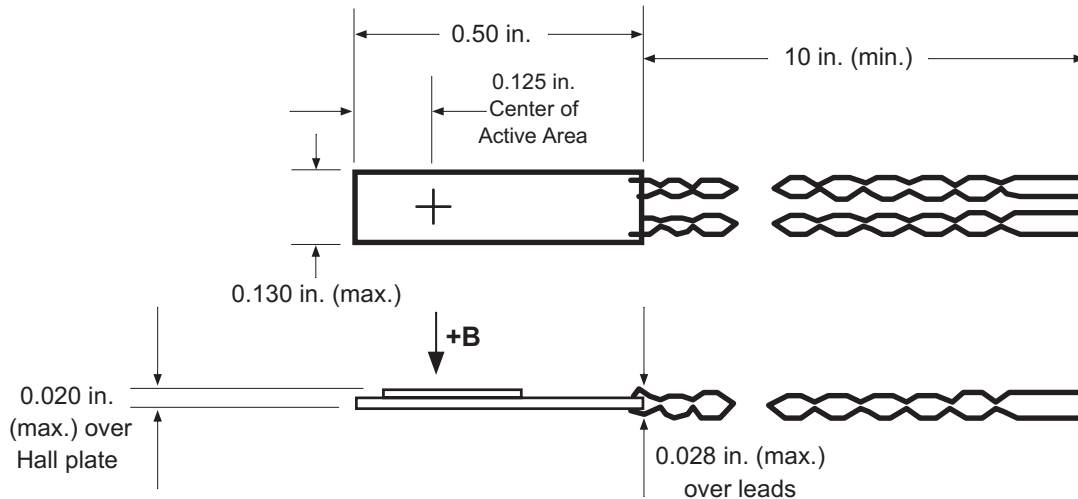**Figure C-5. Axial Hall Generator HGA-3010, HGA-3030, and HGCA-3020 Dimensions**
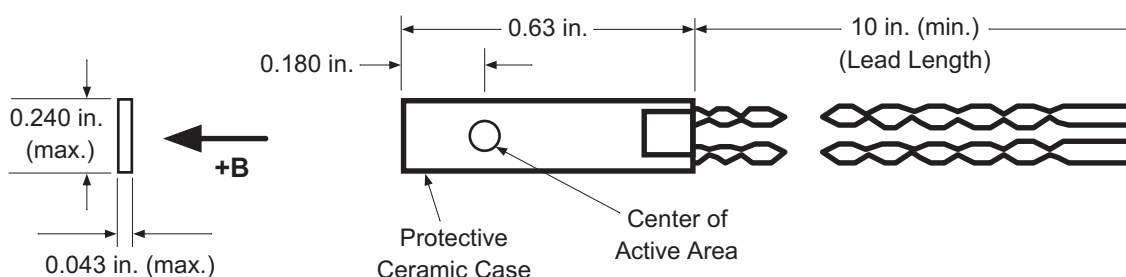
C-421-C-6.eps

Figure C-6. Transverse Hall Generator HGT-3010, HGT-3030, and HGCT-3020 Dimensions

Table C-1. Cryogenic Hall Generator Specifications

Cryogenic	HGCA-3020	HGCT-3020
Description	Cryogenic axial; phenolic package	Cryogenic transverse; ceramic package
Active area (approximate)	0.030 inch diameter circle	0.040 inch diameter circle
Input resistance (approximate)	1 ohm	1 ohm
Output resistance (approximate)	1 ohm	1 ohm
Nominal control current (I_{CN})	100 mA	100 mA
Maximum continuous current (non-heat sinked)	300 mA	300 mA
Magnetic sensitivity (I_C = nominal control current)	0.55 to 1.05 mV/kG	0.55 to 1.05 mV/kG
Maximum linearity error (sensitivity vs field)	±1.0% RDG (-30 to +30 kG) ±2.0% RDG (-150 to +150 kG)	±1.0% RDG (-30 to +30 kG) ±2.0% RDG (-150 to +150 kG)
Zero field offset voltage (I_C = nominal control current)	±200 µV (max.)	±200 µV (max.)
Operating temperature range	4.2 K to 375 K	4.2 K to 375 K
Mean temperature coefficient of magnetic sensitivity	±0.01%/K (approx.)	±0.01%/K (approx.)
Mean temperature coefficient of offset (I_C = nominal control current)	±0.4 µV/K (max.)	±0.4 µV/K (max.)
Mean temperature coefficient of resistance	±0.6%/K (max.)	±0.6%/K (max.)
Leads	34 AWG copper w/Teflon insulation	34 AWG copper w/Teflon insulation

Figure C-7. Transverse Hall Generator HGT-1010 Dimensions

Table C-2. Axial Hall Generator Specifications

Axial	HGA-3010	HGA-3030
Description	Instrumentation quality axial; low temperature coefficient; phenolic package	Instrumentation quality axial; phenolic package
Active area (approximate)	0.030 inch diameter circle	0.030 inch diameter circle
Input resistance (approximate)	1 ohm	2 ohms
Output resistance (approximate)	1 ohm	2 ohms
Nominal control current (I_{CN})	100 mA	100 mA
Maximum continuous current (non-heat sinked)	300 mA	300 mA
Magnetic sensitivity (I_C = nominal control current)	0.55 to 1.05 mV/kG	6.0 to 10.0 mV/kG
Maximum linearity error (sensitivity versus field)	±1% RDG (–30 to +30 kG) ±1.5% RDG (–100 to +100 kG)	±0.30% RDG (–10 to +10 kG) ±1.25% RDG (–30 to +30 kG)
Zero field offset voltage (I_C = nominal control current)	±50 µV (max.)	±75 µV (max.)
Operating temperature range	–40 to +100 °C	–40 to +100 °C
Mean temperature coefficient of magnetic sensitivity	±0.005%/°C (max.)	–0.04%/°C (max.)
Mean temperature coefficient of offset (I_C = nominal control current)	±0.4 µV/°C (max.)	±0.3 µV/°C (max.)
Mean temperature coefficient of resistance	±0.15%/°C (approx.)	+0.18%/°C (approx.)
Leads	34 AWG copper with poly-nylon insulation	34 AWG copper with poly-nylon insulation

Table C-3. Transverse Hall Generator Specifications

Transverse	HGT-1010	HGT-3010	HGT-3030
Description	General purpose transverse; 0.020 inch thick	Instrumentation quality transverse; low temperature coefficient; ceramic package	Instrumentation quality transverse ceramic package
Active area (approximate)	0.040 inch diameter circle	0.040 inch diameter circle	0.040 inch diameter circle
Input resistance (approx.)	2 ohms	1 ohm	2 ohms
Output resistance (approx.)	2 ohms	1 ohm	2 ohms
Nominal control current (I_{CN})	100 mA	100 mA	100 mA
Maximum continuous current (non-heat sinked)	300 mA	300 mA	300 mA
Magnetic sensitivity (I_C = nominal control current)	7.5 to 12.5 mV/kG	0.55 to 1.05 mV/kG	6.0 to 10.0 mV/kG
Maximum linearity error (sensitivity versus field)	±1.0% RDG (-10 to 10 kG)	±1% RDG (-30 to 30 kG) ±1.5% RDG (-100 to 100 kG)	±0.30% RDG (-10 to 10 kG) ±1.25% RDG (-30 to 30 kG)
Zero field offset voltage (I_C = nominal control current)	±100 µV max.	±50 µV max.	±75 µV max.
Operating temperature range	–40 to +100 °C	–40 to +100 °C	–40 to +100 °C
Mean temperature coefficient of magnetic sensitivity	–0.08%/°C max.	±0.005%/°C max.	–0.04%/°C max.
Mean temperature coefficient of offset (I_C = nominal control current)	±1 µV/°C max.)	±0.4 µV/°C max.	±0.3 µV/°C
Mean temperature coefficient of resistance	±0.18%/°C approx.	±0.15%/°C approx.	+0.18%/°C approx.
Leads	34 AWG copper with poly-nylon insulation.	34 AWG copper with poly-nylon insulation	34 AWG copper with poly-nylon insulation

C6.0   HALLCAL.EXE PROGRAM

The HALLCAL.EXE program was developed by Lake Shore Cryotronics, Inc. to allow the interfacing of customer attached Hall generators to the Model 421 Gaussmeter. (Please refer to the Software License Agreement behind the title page of this manual.) This program is provided with the purchase of a Model MCBL-6 or -20 Cable Assembly. Because of the many intricacies involved with proper calibration, the Customer must accept responsibility for the measurement accuracy.

Requirements:

•   Lake Shore Model 421 Gaussmeter (connected via RS-232 to the computer in the COM1 port).

•   Lake Shore Model MCBL-6 or -20 Cable Assembly.

•   IBM or compatible CPU.

•   Hall generator meeting the sensitivity ranges given below.

•   Calibration or sensitivity constant and serial number of the Hall generator.

1.   Set the Lake Shore Model 421 Gaussmeter to 300 Baud. Refer Paragraph 3.11 of this User's Manual on how to set the Gaussmeter to communicate at 300 Baud.

2.   Insert the 3.5-inch disk and type in the default drive (**A:** or **B:**).

3.   Type in **HALLCAL**. This will execute the HALLCAL.EXE program.

4.   The program will prompt for the Probe serial number. Any combination of 6 letters or number can be entered. Press **Enter** when this is accomplished.

5.   The program will prompt for the probe type (0 or 1).

Enter "**0**" for Hall generators with sensitivities between 5.5 and 10.5 mV/kG (@ 100 mA current).

Enter "**1**" for Hall generators with sensitivities between 0.55 and 1.05 mV/kG (@ 100 mA current).

6.   The program will prompt for the "Calibration Constant." Enter the magnetic sensitivity in mV/kG at a control current of 100 mA. Remember to account for the 420 Ω input impedance of the Gaussmeter when calculating the proper load resistor to install.

7.   The program will display all the values entered along with designated F keys:

F1	Probe Serial Number	ABC123
F2	Probe Type	0
F3	Calibration Constant	X.XXX
F10	Program Probe	
Esc	Exit Program	

8.   At this time, if any of the parameters need to be changed, just press the appropriate F key and type in the new value. When everything appears correct, press F10 to program the probe.

9.   It takes about 20 seconds to program the probe. After the probe is programmed, press the **Esc** key to exit the program.